TURFGRASS PESTS

CALIFORNIA AGRICULTURAL
EXPERIMENT STATION
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MANUAL 44
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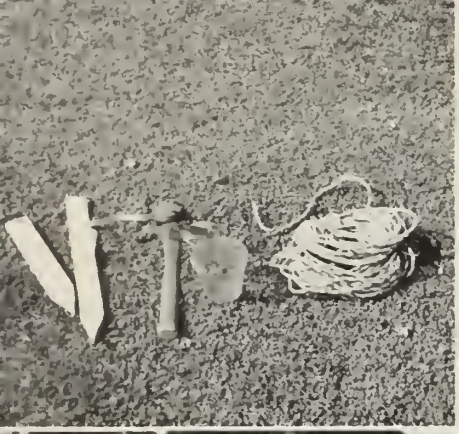

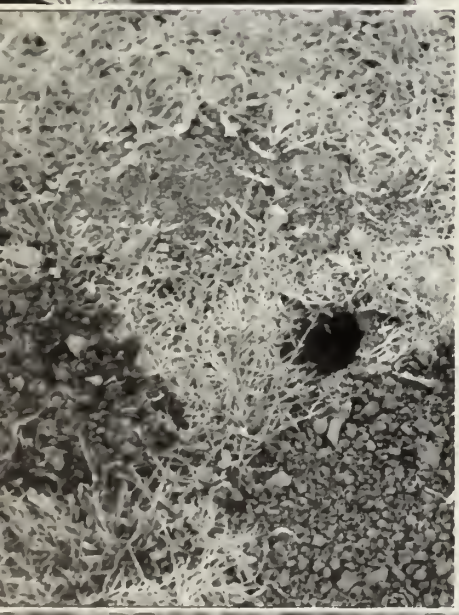

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PREFACE

This manual is written so that anyone concerned with the growing of turfgrass can identify and control many of the serious pests invading turfgrasses. The authors have provided sufficient information and pictures to aid in identification of these pests. Calendars of pest activity and treatment will be useful in control measures.

Correct *identification* and *selection* of the best pesticide for control is of utmost importance; but paralleling this is the correct *use* of these materials. The section on pesticide calculations will be of value in determining the correct amounts of chemical and water to use. The glossary provides information necessary for a clear understanding of terms used with pests and pesticides.

Most pesticides are poisonous. The section on chemical safety should be read carefully and the directions followed closely.

Knowledge is expanding at a rapid pace. Universities and private research agencies throughout the world continue to produce new information and chemicals to provide more effective pest control. Unfortunately, in spite of this new pests seem to somehow make their uninvited and unwelcomed appearance. As new pests are discovered and new control recommendations are made, they will be announced through the University of California Farm Advisor offices (see below).

Many turfgrass authorities have stated that "a healthy grass is the best means of pest control." Before seeking chemical methods to control pests, the wise manager will also determine if better turfgrass management practices can be employed to help reduce pest problems.

It should be emphasized that "as a chain is no stronger than its weakest link," pest control practices will be no more effective than the attention paid to the least detail.

This publication was made possible by the work of many people. The authors express their appreciation to all persons who have contributed to the identification and control of the pests of turfgrasses.

* * * * * * * * * * * *

It is necessary to control some pests of turfgrass by using chemicals. However, developments in the field of chemistry are taking place so rapidly that no specific recommendations for the use of chemicals can be made in this manual.

Such recommendations are made in a free, leaflet-type publication that is revised and re-issued as needed. Copies may be obtained from the University of California Farm Advisor offices, or from

Agricultural Publications
University of California
Berkeley, Calif. 94720

Ask for Leaflet 209.

University of California • Division of Agricultural Sciences

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SAFE and EFFECTIVE USE of PESTICIDE CHEMICALS

J. Blair Bailey

Pesticides are not only useful, but in many cases absolutely necessary for production of pest-free turfgrass. We can benefit from their *proper use.* If misused, however, *through carelessness or lack of knowledge,* the result can be expensive and even dangerous.

Before discussing the problems that can result from misuse, let's first have clearly in mind what pesticides are, and in general terms, how they work.

What is a pesticide?

The term "pesticide," defined legally as an "economic poison," refers to any chemical or mixture of chemicals intended for controlling pests. For example:

TYPES OF PESTICIDES USED	TYPES OF PESTS CONTROLLED
Insecticides	Insects
Fungicides	Fungi and Bacteria
Herbicides	Weeds
Nematicides	Nematodes
Rodenticides	Rodents

How they work

In general, pesticides control both plant and animal pests by poisoning them. Thus all pesticides are toxic (poisonous) to one degree or another to plants or animals, and sometimes to both. Since humans are animals, pesticides are poisonous to them too. Some pesticides are poisonous to, and can kill, helpful plants or animals such as livestock, pets, fish, and honeybees.

Some pesticides are more toxic than others. All of the chemicals recommended in Leaflet 209 are given *toxicity ratings* so you will know which ones are most toxic. You should be especially careful with these materials and take the precautions outlined here and on the label of the pesticide container.

Chemicals that present special problems will be discussed below.

Follow recommendations carefully and do exactly what they say

Before handling any pesticide read and understand all of the information on the pesticide label! If you need help ask for it! Know what to do in case of an accident. The authors of each section of this manual have given their recommendations for safely and effectively controlling specific pests. Follow them.

Use the correct chemical

It is essential to your personal safety and the safety of others, as well as all beneficial plants and animals, that when a *specific chemical* is recommended, you use it. These chemicals have been tested and proven to be effective in controlling specific pests.

Use the correct amount

When directions say use a *given amount* of the chemical, use *only* that amount. Adding "a little extra" will not control the pest any better and it may cause injury to the treated area (burn the turfgrass) or result in serious drift or other contamination problems.

Use at proper time and temperature

When directions say to apply the chemical at a specific time of the day, or within a given temperature range, or at a certain stage of plant growth, they mean just that. Again, experiments and experience have shown these specific times of application give safest and best control of the pest.

Use recommended form of chemical

Use *only* the formulation of the chemical recommended (wettable powder, dust, emulsifiable concentrate, granular, or gas fumigant). This is important for good pest control. In addition, plant injury (phytotoxicity) may result from the use of a different formulation of the same chemical.

Use proper method of application

Applying the chemical in a prescribed manner is likewise important for effective control and safety. For example, if you are applying a chemical with a tractor-powered unit, and directions are given to travel at a given speed, do just that.

Increasing your speed will very likely result in less chemical being applied to a given area. This may result in poor, or no control of the pest. If you travel slower than prescribed, more chemical will be deposited in a given area and you may "burn" the turfgrass, and leave so much chemical residue that plant growth will be stunted. You could even prevent any plant growth in this soil for a long time afterward.

Do not combine chemicals unless recommendations say it is safe

Mixtures of certain chemicals can cause plant injury, run-off, reduced control of the pest, or clogging of application equipment. Mixtures sometimes even *increase* the toxicity of the chemicals. Check the label of the pesticide container or a compatibility chart *before* you combine pesticides.

How toxic are the pesticides recommended?

You don't have to be a chemist or a toxicologist to understand approximately how toxic a pesticide is. This information is given on the label of the pesticide container

in the form of a symbol, or one or two words in extra large print known as signal words.

SIGNAL WORD(S) OR SYMBOL	APPROXIMATE TOXICITY
"Danger," "Poison" and skull and crossbones symbol	Highly toxic
"Warning"	Moderately toxic
"Caution"	Slightly toxic
No special signal words or symbols	Still less toxic

NOTE: Even though you may find no special "signal words" printed on the label of the pesticide you plan to use, you should treat the chemical as a poison. Even those having a low toxicity rating can cause toxic reactions in you if used in large quantities and often.

Splashes and spills of chemicals

As an applicator you are not likely to eat or drink a pesticide unless by accident. You may, however, accidentally splash or spill the chemical on your skin or in your eyes. This is by far the most common source of poisoning to those handling pesticides. Therefore, your greatest concern should be how toxic (poisonous) the chemical will be to you if it gets on your skin or in your eyes. This is referred to as "Dermal Toxicity." The effects a pesticide will have on *you* are mainly determined by:

- How much gets on you.
- How long you let it stay on you.
- Concentration of the chemical.
- Toxicity of the chemical.
- Formulation of the chemical.

A *few drops* of a highly toxic, highly concentrated, liquid formulation can be highly toxic *to you*, if it splashes or spills on your skin or in your eyes. If this occurs, *stop immediately* and rinse your eyes with clean water for 10–15 minutes. If the chemical gets on your skin, *wash thoroughly* with soap and water. Then call your doctor and tell him what happened giving him the name of the chemical, as printed on the package. *Remember, the longer you leave the chemical on your skin the more damage it can do to you.* Liquid formulation containing solvents, such as xylene, oils, and other petroleum hydrocarbons are absorbed by the eyes and skin much more rapidly than are dusts, wettable powders, or granular forms of these chemicals.

Use *special caution* when pouring and weighing concentrated materials. They are most hazardous *before* dilution. However, even diluted chemicals can accumulate on your skin, hair, clothing, and shoes, so wash and change your clothing after application. If you are given a choice of chemicals to control a pest, select the one that is least hazardous to you, and that will still control the pest.

Before handling any pesticides wear clean, protective clothing, waterproof hat, boots, and goggles. Avoid inhaling (breathing) chemicals, especially those in dust and gas form. Wear a clean, well-fitted, approved respirator when handling sprays and dusts. Wear approved *gas mask* when handling fumigants. Check the labels on the pesticide container for these precautions *before* you handle *any* pesticide. A list of approved respirators and gas masks may be found in the University of California Pesticide Information and Safety Manual.

What to do after a pesticide application

Clean your application equipment and put it back in good working order

Store your pesticides properly:
In the *original, labeled container;* never in or near food, feed, or drinking containers.
In a locked, well-marked storage cupboard or building, never where they will get hot, or freeze.

Dispose of used pesticide containers properly:
Return 30 and 55 gallon drums to original supplier or have a drum reconditioner pick them up as soon as possible. Store them in a place where no unauthorized person can get to them until you can get rid of them safely. Rinse all nonreturnable, glass, metal, and plastic containers with soap and water. Make sure you pour the rinse water in a place where it won't contaminate water supplies or damage crops. Then break or puncture them so they cannot be reused. Empty containers that will burn, should be burned. But make sure it is legal to burn in your area, and stand out of the smoke fumes. Never burn containers that held hormone-type (2,4-D) weed killers. The fumes from these can drift for miles and injure plants.

Keep good records of all pesticide applications

Do this immediately after the application, before you forget the details. Record what was treated; the pest treated; the location and amount of area treated; time of day, date of application; exact name of pesticide used, including type of formulation; amount used per gallon or unit of area treated; and the weather conditions.

For more detailed information on these and other pesticides you are referred to the *University of California Pesticide Information and Safety Manual* which is available at $2.50 from the University of California Agricultural Extension Service, Berkeley, California 94720.

For large spraying or dusting jobs the operator should wear protective clothing—of material that can be easily washed off.

CALCULATIONS and MEASUREMENTS

Wayne C. Morgan

This manual is mainly for operators and caretakers of large areas of lawn and turf and many of the directions given for applying chemicals will state "... apply at the rate of (so much) per acre." The same may be true in other turfgrass publications or on the labels of containers of chemicals bought in large quantities.

But many times, the area to be treated is relatively small and the margin between using enough of a material to be effective and too much material (which might damage the turf) is rather narrow. So it is important that measurements and directions be followed as closely as possible when applying chemicals.

This section tells how to calculate and measure chemicals for different size plots when the directions tell only how much to apply on large areas. Any rates given here are *examples* only; they are *not recommendations.*

How to convert from large areas and/or amounts to smaller ones

Because many recommendations are made on a per-acre basis, the amounts of a pesticide required are often in larger amounts, such as pints (pts.) or pounds (lbs.). First, the area conversion should be reduced to a convenient one and then the materials amounts changed to other equivalents usable for smaller areas.

When using acre figures, round off an acre (43,560 sq. ft.) to 44,000 square feet (sq. ft.). Often for turfgrasses, recommendations are on a "per 1,000 sq. ft." basis; therefore, this is 1/44 of an acre. Dividing the acre rates by 44 will give the amounts needed for 1,000 sq. ft.

To further reduce areas or amounts to 100 sq. ft. units, divide by 10. Any other measurements can then be easily adjusted from this basis by additional multiplication or division. If 1 lb. (16 dry oz. by weight) or 1 pt. (16 fluid oz. by volume) were recommended for 1,000 sq. ft., this would be 1.6 oz. per 100 sq. ft. ($16 \div 10 = 1.6$). For an area 350 sq. ft. in size, this is 5.6 oz. ($1.6 \times 3.5 = 5.6$ oz.).

Recommendations are sometimes made for the main ingredient of a mixture in terms of active or actual ingredient. Pesticides are usually sold under trade names containing only certain percentages and/or pounds of the active ingredient. The rest of the mixture will be "inert" or non-active ingredients. These must be adjusted to the amounts of material needed to make one whole unit active ingredient such as a pint or pound.

A small gram scale and/or household scale with divisions of ounces will be needed for small measurements. When liquid materials are used, it would be well to have measuring cups with divisions of ounces, measuring spoons, and a graduated cylinder in milliliters, obtainable for a small cost at most drug stores.

The labels of most pesticides not only state the percentage concentration but also the number of ounces of active ingredient per gallon of the formulation. The latter is more important in computing dosages.

To determine how many units of active ingredient are in the container when only a certain percentage of the active ingredient is given, multiply the size or weight of the container by the percentage written as a decimal for this information. Thus 1 gal. $\times$ 0.40 = 0.4 gallons, or since there are 128 ounces in a gallon, this is 128 ounces $\times$ 0.40 = 51.2 ounces of active ingredient in one gallon of 40% material.

Formulations of the same pesticides often vary in concentration of active ingredients depending upon the manufacturer, so it is necessary for the person using the pesticide to compute the amount of formulation needed to give the amount of active ingredient called for in the recommendation. The various emulsifiable pesticide concentrates usually contain the following amounts of active ingredients per gallon (by weight):

15% – 18.5%	= 1.5 lb. per gallan
20% – 25%	= 2 lb. per gallon
40% – 45%	= 4 lb. per gallan
50% – 57%	= 5 lb. per gallon
58% – 67%	= 6 lb. per gallon
72% – 78%	= 8 lb. per gallon

Tables 1 and 2 will be helpful if you are called upon to convert from printed directions that say "Use (so many) pounds per acre," and you wish to apply the material to an area of from 100 to 1,000 square feet.

Measuring small amounts

For treating small areas with chemicals it is often necessary to measure out 1/44 of a pint or 1/44 of a pound. This will require you to have the gram scale or the cylinder graduated in milliliters discussed in box at left. Then by consulting the table of conversion figures given below the job becomes easier.

As an example: If a dosage recommendation calls for applying 1.6 oz. to 100 square feet of turf, convert the ounces to grams. ($1.6 \times 28.4 = 45.44$ grams.)

You could round off the 45.44 grams to 45.5 for convenience, but if you rounded off the 1.6 oz. to 1.5 it would amount to a reduction in dosage that might affect the efficiency of the treatment.

Rounding off measures

Even small rounding off of figures can make substantial changes in the rate of application, especially when small quantities per acre are used or the units of measurement

TABLE 1

GRAMS TO USE PER 100 SQUARE FEET FOR DRY MATERIALS AT CERTAIN PERCENTAGES OF ACTUAL INGREDIENTS, WHEN RECOMMENDATIONS ARE GIVEN IN POUNDS PER ACRE

Recomm. in pounds per acre	Per cent of actual ingredient given on label										
	100%	90%	80%	70%	60%	50%	40%	30%	20%	10%	5%
	No. of grams to use per 100 sq. ft.										
1	1.04	1.15	1.3	1.49	1.73	2.08	2.6	3.47	5.2	10 4	20.8
2	2.08	2.30	2.6	2.98	3.46	4.16	5.2	6.94	10.4	20.8	41.6
3	3.12	3.45	3.9	4.47	5.19	6.24	7.8	10.41	15.6	31.2	62.4
4	4.16	4.60	5.2	5.96	6.92	8.32	10.4	13.98	20.8	41.6	83.2
5	5.20	5.75	6.5	7.45	8.65	10.40	13.0	17.45	26.0	52.0	104.0
6	6.24	6.90	7.8	9.94	10.38	12.48	15.6	20.82	31.2	62.4	124.8
7	7.28	8.05	9.1	11.43	12.11	14.56	18.2	24 29	36.4	72.8	145.6
8	8.32	9.20	10.4	11.92	13.84	16.64	20.8	27.96	41.6	83.2	166.4
9	9.36	10.35	11.7	13.41	15.57	18.72	23.4	31.23	46.8	93.6	187.2
10	10.40	11.50	13.0	14 90	17.30	20.80	26.0	34 70	52.0	104.0	208.0

TABLE 2

CUBIC CENTIMETERS TO USE PER 100 SQUARE FEET FOR LIQUID MATERIALS WHEN ACTIVE INGREDIENT IS STATED IN POUNDS PER GALLON, AND RECOMMENDATIONS ARE GIVEN IN POUNDS PER ACRE

Recomm. in pounds per acre	Pounds per gallon active ingredient given on label										
	10	9	8	7	6	5	4	3	2	1	.5
	No. of CC to use per 100 sq. ft.										
1	0.84	0.96	1.08	1.23	1 43	1.68	2.15	2.88	4.30	8.6	17 2
2	1.68	1.92	2 16	2.46	2.86	3.36	4.30	5.76	8.60	17.2	34.4
3	2.52	2.88	3.24	3.69	4.29	5.04	6.45	8.64	12.90	25.8	51.6
4	3.36	3.84	4.32	4.92	5 72	6.72	8.60	11.52	17.20	34 4	68.8
5	4.20	4.80	5 40	6.15	7.20	8.40	10.75	14.40	21.50	43.0	86.0
6	5.04	5.76	6 48	7.38	8.58	10.08	12.90	17.28	25.80	51.6	103.2
7	5.88	6.72	7 56	8.61	10.01	11.76	15.05	20.16	30.10	60.2	120.4
8	6.72	7.68	8.64	9.84	11 44	13.44	17.20	23.04	34.40	68.8	137.6
9	7.56	8.64	9.72	11.07	12.87	15.12	19.35	25.92	38.70	77.4	154 8
10	8.40	9.60	10.80	12.30	14.30	16.80	21.50	28.80	43.00	86.0	172.0

are larger. This may seriously alter the effectiveness of the pesticide or subject desirable plants to injury.

If 12 pints or pounds to the acre were recommended, the following is how rounding off of rates for 200 sq. ft. would affect the amounts being applied:

1.6 oz. to 1.5 oz. = a reduction of 20 oz. per acre or only 10.75 pints or pounds being applied per acre rather than the 12 pints or pounds recommended.

3.17 tbsp. to 3 tbsp. = a reduction of 34 tbsp. or 17 oz., a little over a pint less than the 12 pints recommended.

9.6 tsp. to 9.5 tsp. = a reduction to 20 tsp. or about 7 tbsp. (7½ oz.). This would be about 11.75 (11¾ pts.) to the acre being used.

47.4 ml. or gms. to 47.5 ml. or gms. = an increase of 20 ml. or gms. per acre, which is less than .1 or 1% increase.

In using the teaspoon, milliliter, or gram measurements, the differences in rates applied would not have been significant.

Examples

Here are some typical examples of conversion from figures where the recommendations are given for large areas but only a relatively small area needs treatment.

Problem 1. A recommendation calls for the rate of 4 oz. (0.25 lb.) active ingredient per 1,000 sq. ft. The material is available as a 25% emulsifiable concentrate

TABLE 3

CONVERSION FIGURES

DRY WEIGHT

1 pound (lb.)	=	16 ounces (oz.)
1 pound	=	454 grams (gms.)
1 ounce	=	28.4 grams (gms.)

LIQUID MEASURE (VOLUME)

1 gallon (gal.)	=	128 ounces
1 quart (qt.)	=	32 ounces
1 pint (pt.)	=	16 ounces
1 cup	=	8 ounces
1 tablespoon (tbsp.)	=	½ ounce
3 teaspoons (tsp.)	=	1 tablespoon
16 fluid ounces	=	473 milliliters*
1 fluid ounce	=	29.57 milliliters*
1 qt. water/100 sq.ft.	=	110 gals./acre

* 1 milliliter is equivalent to 1 cubic centimeter.

Note: It may be helpful to determine how many level teaspoons of material are needed to make 1 ounce or how many grams there are in a teaspoonful, and then use volume measurements for ease in future use.

(contains 2 lbs. per gal.). How much of this formulation will be needed to provide the 4-oz. active ingredient for 200 sq. ft. of lawn area? How much water would be needed if this was to be applied in 110 gals. per acre?

Solution. First use this formula

$$\frac{\text{Lbs. active ingredient desired per unit of area} \times \text{fluid ounces in one gallon}}{\text{Lbs. active ingredient in the emulsifiable concentrate}} = \text{Fluid ounces of formulation needed per unit of area}$$

$$\frac{0.25 \times 128}{2} = 16 \text{ fl. oz. or } 473 \text{ ml } (16 \times 25.47 \text{ ml/oz} = 473 \text{ ml}) \text{ per } 1{,}000 \text{ sq. ft.}$$

As 200 sq. ft. is 20% of 1,000 sq. ft. (200 ÷ 1,000 = 0.20 or 20%) then by multiplying each measure by 0.20 the amount needed for the 200 sq. ft.-area is found: 16 oz. × 0.20 = 3.2 oz. or 473 ml × 0.20 = 94.6 ml. Using teaspoon and tablespoon equivalents this would be 3.2 oz. = about 18¼ tsp. or 6 tbsp. + about ¼ tsp.

Since 1 qt. of water per 100 sq. ft. is equal approximately to 110 gals. per acre, then 2 qts. of water would be needed for the 200 sq. ft. of lawn area.

Problem 2. The recommendation is for 18 pounds of active ingredient per acre. A dry granular material containing 45% active ingredient is to be used. How much is needed for 740 sq. ft. area?

Solution. 18 pounds equal 288 oz. or 8,172 gms. For 1,000 sq. ft. this would be about 6.5 oz. (288 ÷ 44 = approximately 6.5 oz.) or 186 gms (8172 ÷ 44 = approximately 186 gms.). Since 740 sq. ft. is almost ¾ of 1,000 sq. ft. this means about 4.9 oz. (6.5 oz. × 0.75 = approximately 4.9 oz.) or 139.5 gms (186 gms. × 0.75 = 139.5 gms.) of active ingredient would be needed for the 740 sq. ft. area.

The granular material contains only 45% active ingredient, so to have 1 oz. of active ingredient, about 2.2 oz. (100 ÷ 45 = about 2.2 oz.) of the 45% material would be required. With 4.9 oz. or 139.5 gms. of active ingredient being needed, about 10.70 (4.9 oz. × 2.2 = 10.78 oz.) or 307 gms. (139.5 gms. × 2.2 = 307 gms.) of the 45% dry granular material would be needed for the 740 sq. ft. area.

If it had been determined that 8 tsp. of the 45% material equalled 1 oz. or there were 3½ gms. in 1 tsp., this would be 86.4 tsp. (10.78 × 8 tsp. = 86.4 tsp.). Rounding off to 29 tbsp. or a 15-oz. volume measure would not significantly affect the results.

Problem 3. Same problem as above, using "constants" in a simplified formula.

$$\frac{.03673 \times R \times A}{\%} = \text{oz. of per cent material needed for given area,}$$

Where R = rate needed in lbs. per acre

A = given area

% = per cent of active ingredient in material to be used (taken from label)

$$\frac{.03673 \times 18 \times 740}{45} = 10.76 \text{ oz. of 45 per cent material applied to 740 sq. ft. is equal to 18 lbs. of active ingredient per acre}$$

Problem 3b. Same problem as above but a liquid material with 3 lbs. active ingredient per gallon is used rather than a 45% active granular material.

Solution. A simplified formula for liquid materials is:

$$\frac{.0029 \times R \times A}{\text{lbs./gal.}} = \text{fluid oz. of liquid material needed for given area}$$

lbs/gal = lbs. of active ingredient per gallon (taken from label)

$$\frac{.0029 \times 18 \times 740}{3} = 1.29 \text{ fluid oz. of a 3 lbs. active per gallon material applied to 740 sq. ft. is equal to 18 lbs. active ingredient per acre.}$$

Note: if pints or quarts are used, multiply lbs. active per pint by 8 or lbs. active per quart by 4 to change to lbs. active per gallon.

Problem 4. (Using Table 4.) (a) If the label on a liquid pesticide called for 1 gal. of the material to be applied in 100 gals. of water per acre, how much would be needed for a 430 sq. ft. area? (b) How much would be needed for a 1,500 sq. ft. area?

Solution. (a) (Using Table 4.)—Since 430 sq. ft is approximately $\frac{1}{100}$ of an acre (44,000 ÷ 430 = approximately 100), then only 1 gal. of water with 2½ tbsp. or 37.9 ml. of the material need be applied. (b) (Not using table)—The 1,500 sq. ft. is about $\frac{1}{29.3}$ (44,000 ÷ 1,500 = 29.3) of an acre. By dividing the number of gallons of water needed by the area being used (100 gal. ÷ 29.3) and the amount of material by the area to be covered (1 gal. or 128 oz. ÷ 29.3) it is found that 3.41 gals. (3 gals. + 1 qt. + 1 pt. and 4½ oz.) of water with 4.37 oz. (about 8 tbs. + 2 tbs.) of the liquid pesticide would be needed for a 1,500 sq. ft. area.

Problem 5. (Using Table 5.) (a) A wettable powder is to be used at the rate of 3 lbs. in 25 gal. of water to cover 10,000 sq. ft. What would be needed for a 2,000 sq. ft. area? (b) What would be needed for a 100 sq. ft. area?

Solution. (a) (Using Table 5.) Since 2,000 sq. ft. is 20% of 10,000 sq. ft. (2,000 ÷ 10,000 = .20 or 20%) and 20% of 25 gals. is 5 gals. by looking across the 5-gal. row to the 3 lbs. column, it is seen that 2.4 oz. or 68 gms. would be the rate for 2,000 sq. ft. (b) (Not using table)—One hundred sq. ft. is $\frac{1}{100}$ of 10,000 sq. ft. Twenty-five (25) gals. equals 3,200 oz. Three (3) lbs. equals 1,362 gms. Each 100 sq. ft. would then need 32 oz. (3,200 ÷ 100 = 32 oz.) of water with 13.62 gms. (1,362 ÷ 100 = 13.62) of wettable powder.

TABLE 4

PROPORTIONATE AMOUNTS OF LIQUID CHEMICALS NEEDED WHEN RECOMMENDATION IS GIVEN FOR 100 GALLONS OF WATER*

Quantity of water needed	Quantity of liquid chemical needed				
100 gallons	1 cup	1 pint	1 quart	2 quarts	1 gallon
25 gallons	4 tablespoons (59.2 ml.)	½ cup	1 cup	1 pint	1 quart
10 gallons	5 teaspoons (23.7 ml.)	3 tablespoons (47.3 ml.)	6⅔ tablespoons (94.6 ml.)	13 tablespoons (189.3 ml.)	1½ cups (378.5 ml.)
5 gallons	2¼ teaspoons (11.8 ml.)	4½ teaspoons (23.7 ml.)	3 tablespoons (47.3 ml.)	6⅔ tablespoons (94.6 ml.)	13 tablespoons (189.3 ml.)
3 gallons	1½ teaspoons (7.1 ml.)	3 teaspoons (14.2 ml.)	5½ teaspoons (28.4 ml.)	3⅔ tablespoons (56.8 ml.)	7½ tablespoons (113.6 ml.)
1 gallon	½ teaspoon (2.4 ml.)	1 teaspoon (4.7 ml.)	2 teaspoons (9.5 ml.)	4 teaspoons (18.9 ml.)	2½ tablespoons (37.9 ml.)
1 quart	.....	¼(—) teaspoon (1.2 ml.)	½ teaspoon (2.4 ml.)	1 teaspoon (4.7 ml.)	2(—) teaspoons (9.5 ml.)

* Adapted from "Handbook of Agricultural Pest Control" by S. F. Bailey and L. M. Smith.

TABLE 5

PROPORTIONATE AMOUNTS OF POWDERED MATERIALS NEEDED WHEN RECOMMENDATION IS GIVEN FOR 100 GALLONS OF WATER*

Quantity of water needed	Quantity of powdered material needed			
100 gallons	1 pound	2 pounds	3 pounds	5 pounds
25 gallons	4 ounces	8 ounces	12 ounces	20 ounces
10 gallons	1.6 ounces (45.4 grams)	3.2 ounces (90.7 grams)	4.8 ounces (136.1 grams)	8 ounces (226.8 grams)
5 gallons	0.8 ounce (22.7 grams)	1.6 ounces (45.4 grams)	2.4 ounces (68.0 grams)	4 ounces (113.4 grams)
3 gallons	½ ounce (—) (13.6 grams)	1.0 ounce (—) (27.2 grams)	1.4 ounces (40.8 grams)	2.4 ounces (68.0 grams)
1 gallon	4.5 grams	9.1 grams	13.6 grams	22.7 grams
1 quart	1.1 grams	2.3 grams	3.4 grams	5.7 grams

* Adapted from "Handbook of Agricultural Pest Control" by S. F. Bailey and L. M. Smith.

Problem 6. (Using Table 6.) (a) The recommendation called for a dilution of 1 part material to 600 parts of water. If 225 gals. of water per acre are to be used, how much material would be needed? (b) How much water and material would be needed for 1,000 sq. ft.?

Solution. (a) (Using Table 6.) A dilution of 1 to 600 for 100 gals. is ⅔ qt. (1⅓ pt.) and for 25 gals. is ⅓ pt. Two-hundred gals. would then be 2⅔ pts. (1⅓ pt. × 2 = 2⅔ pts.); and by adding ⅓ pt. for 25 gals. this equals 3 pts. (2⅔ + ⅓ = 3 pts.) which would be needed in the 225 gals. for 1 acre. (b) (Using Problem (a) results)—One-thousand sq. ft. is about 1/44 of an acre. Changing the 3 pts. to oz., this equals 48 oz. The amount of water needed per 1,000 sq. ft. would be 5.1 gals. or 5 gals.. 13 oz. (225 ÷ 44 = 5.1 gals.) with about 1.1 oz. (48 oz. ÷ 44 = about 1.1 oz.) of the liquid material.

Problem 6. (Using Table 7.) (a) A recommendation calls for 2.75 pounds of material per 100 gals. of spray. How much would be needed for 15 gals.? (b) If 64 oz. of spray are needed in 100 gals. to cover ½ acre, how much material would be needed and how many gallons of

TABLE 6

EQUIVALENT QUANTITIES OF LIQUID MATERIALS FOR DILUTION IN PARTS OF WATER*

Quantity of water in gallons	Dilution (parts)					
	1 to 200	1 to 400	1 to 600	1 to 800	1 to 1000	1 to 1600
100	2 quarts	1 quart	⅔ quart	1 pint	1½ cups	½ pint
25	1 pint	1 cup	⅓ pint	½ cup	6⅔ tablespoons	4 tablespoons
5	6⅔ tablespoons	3⅓ tablespoons	6½ teaspoons	5(—) teaspoons	3¾ teaspoons	2½ teaspoons
1	4 teaspoons (18.9 ml.)	2 teaspoons (9.5 ml.)	1⅓ teaspoons (6.3 ml.)	1 teaspoon (4.7 ml.)	¾ teaspoon (3.8 ml.)	½ teaspoon (2.4 ml.)

* Adapted from "Handbook of Agricultural Pest Control" by S. F. Bailey and L. M. Smith.

TABLE 7

AMOUNTS OF POWDERED MATERIAL (BY WEIGHT) NEEDED TO PREPARE DIFFERENT AMOUNTS OF SPRAY MIXTURE AT GIVEN DOSAGE LEVELS

Recommended dosages per 100 gallons			Amount of powdered material needed to prepare:									
			50 gallons		20 gallons		10 gallons		5 gallons		1 gallon	
lb.	*oz.*	*gm.*	*oz.*	*gm.*	*oz.*	*gm.*	*oz.*	*gm.*	*oz.*	*gm.*	*oz.*	*gm.*
0.25	4	113	2	56	0.8	23	0.4	11	0.20	6	0.04	1
0.50	8	227	4	113	1.6	45	0.8	23	0.40	11	0.08	2
1.00	16	454	8	227	3.2	91	1.6	45	0.80	23	0.16	5
1.50	24	681	12	340	4.8	136	2.4	68	1.20	34	0.24	7
2.00	32	908	16	454	6.4	182	3.2	91	1.60	45	0.32	9
3.00	48	1362	24	681	9.6	272	4.8	136	2.40	68	0.48	14
4.00	64	1816	32	908	12.8	363	6.4	182	3.20	91	0.64	18
5.00	80	2270	40	1135	16.0	454	8.0	227	4.00	113	0.80	23

spray for ¼ acre? (c) How much material and spray are needed for each 100 sq. ft. of Problem (b)?

Solution. (a) (Using Table 7.)—

DOSAGES PER 100 GALLONS	AMOUNT OF MATERIAL	
lb.	*10 gals.*	*5 gals.*
2.00	91 gm. or 3.2 oz.	45 gm. or 1.6 oz. = 136 gm.
.50	23 gm. or 0.8 oz.	11 gm. or 0.4 oz. = 34 gm.
.25	11 gm. or 0.4 oz.	6 gm. or 0.2 oz. = 17 gm.
2.75	125 gm. or 4.4 oz.	62 gm. or 2.2 oz. = 187 gm.

For 15 gals. of spray that calls for 2.75 lbs. of material per 100 gals. of spray, this would require 187 gm. or 6.6 oz. (b) (Using Table 7.)—If the 64 oz. in 100 gals. of water would cover ½ acre, then ¼ acre is one-half of this; so 50 gals. of spray with 32 oz. of materials are needed. (c) (Not using table)—One-half of an acre is 22,000 sq. ft., so 100 sq. ft. is $\frac{1}{220}$ of this (22,000 ÷ 100 = 220). For each 100 sq. ft. then, about .29 oz. (64 ÷ 220 = 0.29 oz.) of material is needed. The water requirements would be .45 gals (100 gals. ÷ 220 = 0.45 gals.) or 57.6 oz. (128 × 0.45 = 57.6 oz.) for 100 sq. ft.

How to measure the area to be treated

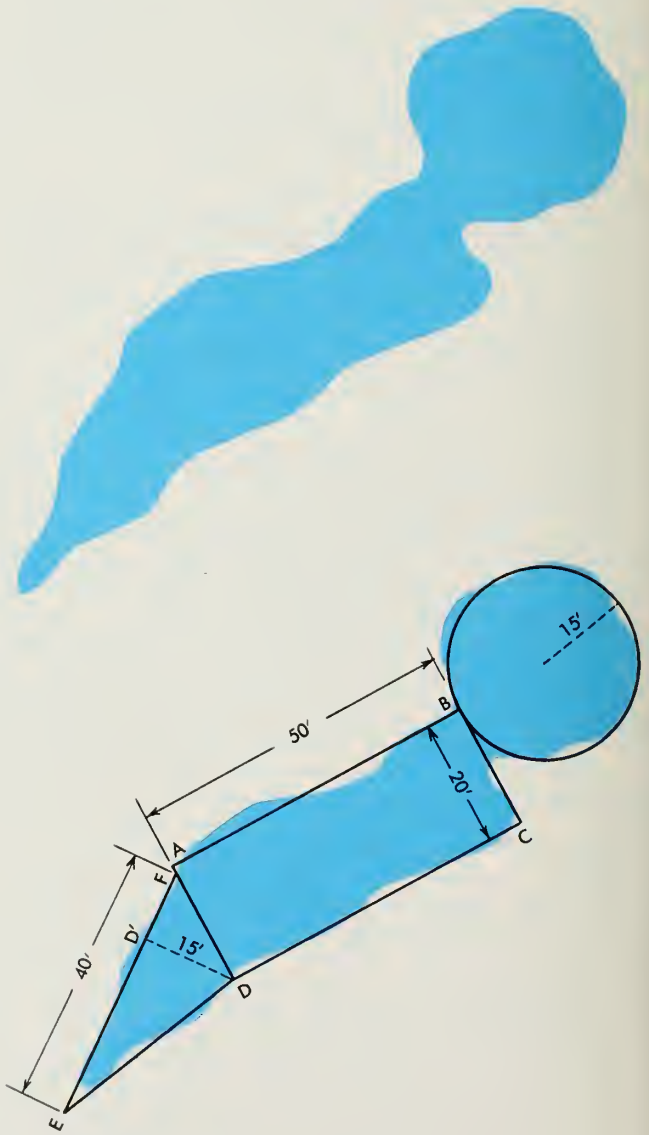
Few, if any areas that need treating will be in nice, regular geometric designs. Practically all such areas will be irregular in shape and may even resemble something like the area shown in blue at the top of column 2.

While it would be difficult for anyone to measure an area like this to within one or two square feet, it is fairly simple to figure it closely enough for practical purposes. Chemicals are expensive and it is well to avoid wasting them by measuring as accurately as you can.

Probably the simplest way to measure an odd-shaped area like the one shown above is to reduce it to simple, geometrical figures, then work out the areas of these from the formulas given below. See bottom of column 2.

Note that you have roughly a triangle, a rectangle, and a circle. If you drive small stakes into the ground at the points indicated by letters it is easy to make the measurements needed.

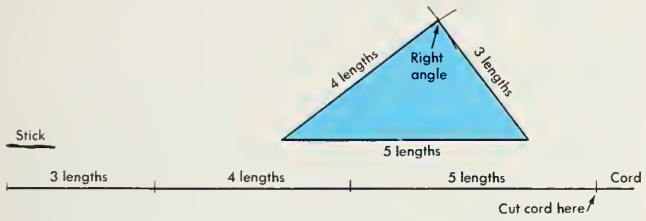
The area of the triangle FDE can be arrived at with the formula base (line EF) multiplied by altitude (line DD′)



divided by 2, or AB. In this case $\frac{40' \times 15'}{2} = \frac{600'}{2}$ = 300′ is the area of the triangle.

Note that line DD′ is drawn from point D so that it is perpendicular (at right angles) to line EF. It is easy to find a right angle with a very simple device you can make with a cord or rope.

Use any convenient stick of wood; measure off three lengths of the stick on your cord and tie a knot at that point. Measure off four more lengths on the cord and tie another knot. Then measure off five lengths and either tie a knot or cut the cord (see diagram).



Bring the end you started measuring from over to the last knot you tied and hold these two points together. Pull the cord out, as shown in the diagram and the angle formed at the second knot you tied will be a right angle. (This trick is thought to have been known to the ancient Egyptians and it still works.)

The area of the rectangle ABCD can be found by multiplying the length (50′) by the width (20′) and comes out to 1.000 square feet.

The remaining plot is almost a perfect circle so to find its area measure the radius (half of the diameter) and use the formula πr^2 (radius times itself) where the symbol π represents the number 3.14.

TABLE 8

AMOUNTS OF LIQUID OR DRY MEASURE TO USE PER 100 SQUARE FEET WHEN RECOMMENDATION IS FOR POUNDS OR GALLONS PER ACRE

Pounds or gallons recommended per acre	Quantity to use per 100 sq. ft.	
	Dry measure	Liquid measure
	Ounces	*Tablespoons*
50	1¾	3½
100	3½	7
200	7½	14½
300	11	22
400	14¾	29½
500	18½	37

EXAMPLE: The recommendation is for 200 pounds of a dry material per acre and you want to treat 350 square feet. Multiply 11 oz. by 3.5 = 38.5 oz. or 2 lbs. and 6.5 oz.

EXAMPLE: The recommendation is for 100 gallons of a liquid material per acre and you want to treat 300 square feet. Multiply 7 tablespoons by 3 = 21 tablespoons. In column 2, this page you will find that 1 tablespoon = ½ fluid ounce so you may use one-half of 21 ounces, or 10½ ounces.

So this circle having a radius of 15′ has an area 3.14 × 15 × 15 or 706.5 sq. ft. You could round that off to 700.

Reduction from Amounts Per Acre to 100 Square Feet Areas

Most directions on labels of chemicals are given in convenient round numbers. To determine the exact calculations for your requirements use Table 8 and some simple arithmetic.

MEASUREMENTS

Linear Measure

1 inch (in.)	= 2.54	centimeters (cm.)
12 inches	= 1	foot (ft.)
3 feet	= 1	yard (yd.)
5,280 feet	= 1	land mile
1,760 yards	= 1	land mile

NOTE: For extreme accuracy in measuring distance, a 50- or 100-foot steel tape is indispensable. However, in many cases distances can be paced off by walking and the resulting figures will be close enough for small areas.

Most men of average height (5′8″ to 5′10″) will take a 30-inch (2½-foot) stride.

Square Measure

144 square inches (sq. in.)	= 1	square foot (sq. ft.)
9 square feet	= 1	square yard (sq. yd.)
43,560 square feet	= 1	acre (165 ft. × 264 ft.)
		(198 ft. × 220 ft.)
		(660 ft. × 66 ft.)
4,840 square yards	= 1	acre
640 acres	= 1	square mile

Liquid Measure

1 fluid ounce (fl.oz.)	= 29.57	cubic centimeters (cc.)*
8 fluid ounces	= 1	cup
2 cups	= 1	pint (pt.)
16 fluid ounces	= 1	pint
1 pint	= 473	milliliters (ml.)
2 pints	= 1	quart (qt.)
4 quarts	= 1	gallon (gal.)

Dry Weight

28.4	grams	= 1 ounce (oz.)
454	grams	= 1 pound (lb.)
16	ounces	= 1 pound
2,000	pounds	= 1 ton

* One cubic centimeter (cc.) is equivalent to one milliliter (ml.)

Household Measure

Where only reasonable accuracy is required. Where teaspoons, tablespoons and cups are used, they should be of the measuring type, not that for tableware use.

1 teaspoon (tsp.)	= ⅙	fluid ounce
3 teaspoons	= 1	tablespoon (tbs.)
1 tablespoon	= ½	fluid ounce
1 teaspoon	= 5	milliliters
1 tablespoon	= 15	milliliters
16 tablespoons	= 1	cup

WEED CONTROL in LARGE TURF AREAS

Clyde L. Elmore and W. B. McHenry

Turf quality depends largely upon one's point of reference. Turf texture and color are usually the important characteristics—the more uniform the texture, the more pleasing the effect. Uniform texture, in addition to a deep green color, is a highly sought after feature of golf course and bowling green turf because it influences the course traveled by the ball. This kind of turf quality requires intensive management to maintain.

For economic reasons, management is less intensive in larger turf areas such as parks thus a mixture of plant species having less uniform texture results. In large areas a turf composed even of nearly all crabgrass has a uniform though coarse texture, and presents a pleasing over-all appearance.

Irregular areas or patches of weeds in turf reduce the beauty and utility. Turf weeds recover from mowing more rapidly than the turfgrass, causing a rough texture in a matter of a few days. Annual bluegrass or ryegrass in the winter: tall fescue or buckhorn plantain in the summer, are examples of weeds that require frequent mowing to maintain a uniform turf species. Weed problems can be reduced or in certain cases eliminated with treatments of herbicides prior to turf establishment. Preplant fumigation of a turf site can kill bermudagrass, nutsedge, other perennials as well as all existing annual plants and many seeds.

Management practices

Weedy turf often results from a breakdown somewhere in the management program. Over or underwatering, mowing too short, low fertility, excessive wear, diseases, insects, soil compaction, excessive shade; all of these allow weeds to invade turf. Any condition that exposes the soil surface to additional light tips the competitive balance in favor of invading weeds.

Mismanagement may include frequent, relatively light irrigations that encourage germination of seeds of annual shallow-rooted weeds such as crabgrass and annual bluegrass. It discourages deep rooting of the turf and weakens its resistance to invasion. Mowing Kentucky bluegrass turf short (below 1½ inches) weakens this turf species and encourages weed growth. Soil that is wet for long periods of time, often resulting from poor drainage, favors red sorrel and annual bluegrass.

When weeds have resulted from poor management, herbicides can be introduced as a management tool to provide a decisive and rapid means of swinging the weed-grass-competition in favor of the turf species. However, unless deficient management practices which encouraged weed invasion are remedied, weeds will again encroach. Herbicides become an important tool in turf management where high-quality turf is desired.

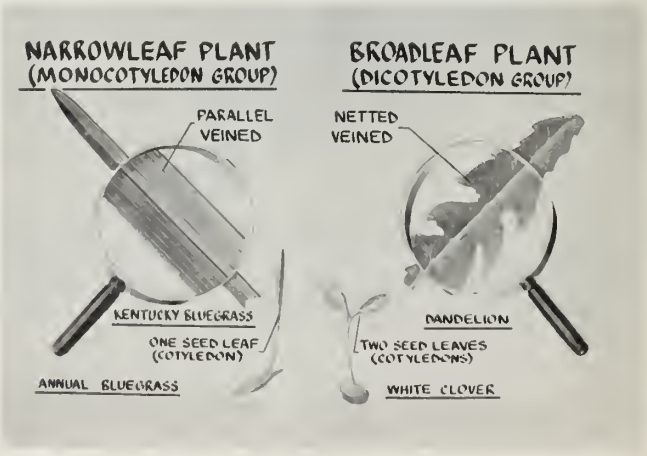
A GLOSSARY . . .
of terms used not only in this manual, but by professional turfgrass operators generally, appears on page 48.

Characteristics and habits of weeds

A weed is a plant growing where its presence is objectionable. Dichondra, a highly prized turf, may be considered an unwelcome intruder, hence a weed in grass turf. Tall fescue is well suited as turf for areas receiving high wear, such as play fields, but when it appears as clumps in Kentucky bluegrass or bermudagrass turf, uniform texture is destroyed and it becomes a weed. Occasionally the terms grasses and weeds are used as two kinds of weeds, but this is unnecessary. *Whether a plant is a grass or broadleaf, if it is out of place and objectionable it is a weed.*

There are about 500 species of weeds in California; the great majority of them are flowering plants, the higher forms of plant life that produce seed. Most of the plants of great economic importance to mankind including wheat, corn, cotton, bluegrass and soybeans are seed-producing plants. Botanists recognize two natural divisions called the monocotyledonae and the dicotyledonae, or more briefly the monocots and the dicots. A familiarity with these plant groups is important to anyone conducting weed control programs.* Since there are only the two plant groups the

* Assistance with weed species identification may be obtained at the local county office of the University of California Farm and Home Advisors Office, or Agricultural Commissioners Office. Local nurserymen are usually acquainted with common weeds in the area.



task is relatively easy. It has been discovered that certain weed killers are, in general, more effective (more active in controlling) one or the other of these two plant groups.

Two characteristics are commonly used to distinguish monocots from dicots. Young seedlings emerge from the soil surface bearing small, green, seedling leaves or cotyledons. The monocots have one seedling leaf; the dicots two. Once the true leaves are formed, the veins or conducting vessels in the leaves can be seen. In the monocots these veins are arranged nearly always in a parallel fashion extending from the leaf base or point of attachment to the tip. In the dicot plants these veins branch in several directions in a netted fashion. Grasses, including Kentucky bluegrass, bamboo, iris, nutsedge, and palms are examples of monocots. Maples, elms, oaks, chickweed, roses, and spotted spurge are members of the dicot group.

Many monocots, particularly grasses, have relatively narrow leaves, while most dicots have leaves that are broader in relation to their length. In weed control terminology these two groups are very often referred to as the *narrowleaf weeds* and *broadleaf weeds*. (Bear in mind that the reference to leaf width is not a literal one, but refers to the two groups of the flowering plants.) Buckhorn plantain, a dicot and common turf weed, although having narrow leaves, under this terminology, is a broadleaf weed. Close inspection shows that the secondary veins in the leaves are netted, not parallel.

Plants are also classed as annuals, biennials, or perennials, depending upon the number of years they live. *Annuals* grow from seed, flower, produce seed, and die in one year or less. There are summer annuals and winter annuals. *Summer annuals* germinate in the spring, grow to maturity during the summer, and die by fall or winter. Barnyardgrass, crabgrass, purslane, knotweed, and goosegrass are summer annuals. Under the mild climate of southern California, crabgrass sometimes lives into a second year. *Winter annuals* germinate in the fall or early winter, overwinter in a vegetative form (without flowering); in the spring they flower and mature a crop of seed and then die. Examples of winter annuals are bur clover, chickweed, yellow starthistle, and annual bluegrass.

Biennials have a life span of two years. The first year's growth is vegetative, usually as a rosette of leaves. During the second year a flower stalk arises, seed is produced, and the plant dies. Bristly oxtongue, and little mallow (cheeseweed) are examples of biennial weeds.

Perennials live and produce seed year after year. Many perennial plants, such as bermudagrass, also reproduce by vegetative means—when stolons or rhizomes are broken from the mother plant, each new unit develops roots and leaves. Raking and pulling will not remove bermudagrass. All of the underground rhizomes must be removed or killed to eliminate this plant.

Perennial species that are in the seedling stage are as readily destroyed as annuals or biennials in the same stage. Less herbicide is required to kill perennials when they are attacked in the seedling stage. Once perennials become established, however, they can be difficult to destroy no matter what management practice is used. Herbaceous perennials, like nutsedge or bermudagrass, have growing points or buds below the soil surface. A contact herbicide, such as weed oil, will completely destroy the above-ground shoots but leave the protected buds below ground undamaged to grow back again.

In planning a weed control program with herbicides economy is important so the lowest effective rate of an appropriate herbicide should be used, and the application should be made at the most susceptible stage in the life history of the weeds. Thus the knowledge of whether the weed species are winter or summer annuals, biennials, or perennials becomes important.

Annuals are the easiest and perennials are the most difficult to destroy. All plants are most vulnerable while in the seedling stage, right after germination, and before they become established plants. A crabgrass seedling will die in a thick, vigorous growth of turfgrasses, because of insufficient sunlight to support adequate photosynthesis. In an open, thin turf, the death of the crabgrass seedling can be brought about by using an appropriate herbicide.

Characteristics of herbicides

Herbicides are chemicals that, because of their peculiar molecular structure, are toxic to plants. Because plants are living organisms, their life processes are complex. Herbicides must find their way into the plant tissues, either via the *roots* or the *shoot* (the above ground part of a plant) in order to disrupt the plant's normal life processes.

Anyone planning to use herbicides in turf must remember that herbicide selectivity (destroying weeds with no undesirable side effects on the turf plants, shrubs, and trees) is entirely relative and depends upon how the herbicides are applied. Even selective herbicides can injure or kill desirable turf or ornamental plants if not used correctly. For this reason herbicide users must follow recommendations in respect to application rate, application timing, and confining the herbicide to the area to be treated—eliminating drift. When using a herbicide for the first time, apply it at the recommended rate, on a limited area to make sure it is successful under your local conditions.

As stated, plants are most susceptible to herbicidal action while in the seedling stage, but this susceptibility can occur with desirable plants as well as weeds. Seedling turfgrass can be seriously stunted or killed with 2,4-D and other herbicides. Most soil-applied herbicides are used preemergent —before germination of the weeds occurs. With few exceptions, herbicides should be used *only* on established turf. As a rule of thumb, a new turf can be considered sufficiently established after it has grown enough to require two mowings.

A single application of an appropriate preemergence, selective, soil-applied herbicide, such as bensulide (Betasan®) or DCPA (Dacthal®) will control crabgrass in turf for an entire growing season. Once the crabgrass has emerged the amount of soil-applied herbicide required to control it would be many times greater; so great that the turf will be severely injured or killed. To control emerged crabgrass and preserve necessary selectivity, a compound like DSMA, which acts on the foliage but has little or no

soil activity, is used. Repeated applications of DSMA, applied 7–10 days apart, are often required to rid the turf of crabgrass.

At least one company markets a mixture of two crabgrass herbicides, a preemergence, soil-applied herbicide, and a postemergence, foliar compound, for use after crabgrass is established. The foliage-active ingredient kills the crabgrass that is present, and the selective, soil-applied herbicide prevents later-germinating crabgrass from becoming established.

Foliage-active herbicides like 2,4-D, dalapon, or DSMA will penetrate the leaves and stems and move within the vessels of the vascular system down to the roots and underground buds. This movement within the plant is called *translocation*. Often a respray is required each time new shoots are formed on perennials in order to get translocation in sufficient concentration to destroy all the buds. A wetting agent, or surfactant, is often added to foliar sprays to aid in penetration into the leaf. Much higher application rates of soil-applied herbicides are required to destroy perennials than are needed for annuals or biennials.

Certain herbicides, such as dalapon, are effective in destroying mainly monocots others like 2,4-D are more effective against the dicots. This preferential toxicity between different plant groups provides much of the selectivity that has made herbicides so useful. Often for each specific weed problem there are several possible herbicides, each differing degree of selectivity, weed toxicity, longevity of control, convenience of use, and price.

Herbicide formulations

Herbicide recommendations suggested by the University of California are given in units of active ingredient (a.i.). This is necessary because herbicides are sold in many different concentrations. Herbicides for the most part are marketed as either dry material or in liquid form. The soil fumigant, methyl bromide, is packaged as a pressurized gas in metal containers.

With dry formulations the strength of the active ingredient is given on the label as a percentage figure. DCPA (Dacthal®) as a wettable powder is 75 percent active. If 15 pounds of active ingredient were called for, 20 pounds of commercial product would be required.

The active ingredient in liquid formulations is expressed in pounds of active ingredient per gallon. A gallon of 2,4-D amine usually contains 4 pounds of active 2,4-D (expressed as the acid equivalent). To apply one pound of active 2,4-D per acre, one-fourth of a gallon, or one quart of the formulation would be needed.

To choose the herbicide or herbicides that will come closest to fulfilling the requirements of a particular weed problem, several approaches have been devised to arrange them in logical groups. The most useful classification is one where herbicides are listed as either *selective* or *nonselective*. The herbicide 2,4-D will control many broadleaf weeds with little or no effect on grass turf when used at recommended rates; it destroys the weeds selectively. However, application rates of 2,4-D that can be used selectively in Kentucky bluegrass or bermudagrass turf may injure bentgrass turf. In bentgrass turf lower rates of 2,4-D must be used to preserve selectivity. The grass killer, dalapon, will control weedy grasses selectively in dichondra when used at recommended rates but is nonselective if applied on grass turf. Herbicide formulation, application rate, stage of growth of desirable plantings to be preserved, temperature, soil moisture status, etc., all affect selectivity in varying degree. Thus selectivity is relative, depending upon the use made of the herbicide. The accompanying table shows that several herbicides can be used selectively or nonselectively.

The next classification is based upon whether the herbicide is used as a foliage spray or as a soil-applied treatment. Some of the spray applied as a foliage treatment will, of course, reach the soil, and soil-active sprays will wet the leaves. However, the compounds classed as *foliage-applied herbicides* act primarily upon the leaves or shoot of the plant. *Soil-applied herbicides* are taken up primarily by the roots and must be carried into the root zone by rain or irrigation to become effective.

Calcium cyanamid is an example of a herbicide that must be mechanically tilled into the soil as a preseeding treatment. This also places the herbicide where the seeds germinate. *Soil fumigants* such as methyl bromide are in reality short-term, soil-applied compounds that require special application techniques (applied under a vapor proof covering such as polyethylene).

TYPES OF HERBICIDE FORMULATIONS

Dry formulations	Examples	How used
Soluble powders	DSMA, amitrole, dalapon	Dissolved in water and sprayed.
Wettable powders	DCPA, diphenamid, dazomet, monuron, terbutol	Suspended in water by stirring, then sprayed. Requires agitation to prevent settling out in tank.
Granular	Calcium cyanamide, DCPA, diphenamid, neburon	Applied dry directly from package using a fertilizer spreader.
Liquid formulations	**Examples**	**How used**
Soluble liquid concentrates	Dicamba, mecoprop, metham, 2,4-D amine, MSMA	Dissolved in water and sprayed.
Emulsifiable liquid concentrates	Bensulide, silvex, 2,4-D ester, bromoxynil	Emulsified with water by vigorous stirring, then sprayed. Requires frequent agitation to prevent concentrate and water from separating.

The final classification of foliar herbicides is based on action of the chemical on the plant. The *translocated* type penetrate into the leaves and stems, move in the vascular system and eventually reach and kill the growing points in both the above ground parts and in the roots. Herbicides that translocate include 2,4-D, MCPP, silvex, dalapon, and DSMA. The less mobile foliar herbicides, like weed oil, cacodylic acid, and paraquat kill only the plant tissues that the spray touches. Movement within the plant beyond the point of contact is relatively limited. These are called *contact herbicides.*

It is important to know whether weeds to be controlled are annuals, biennials, or perennials. This knowledge, coupled with a knowledge of what the various herbicides will or will not do, is essential in conducting an effective and economical weed control program.

How to apply herbicides

Accuracy in application method and rate are very important in all weed control jobs. Excessive herbicide rates are wasteful and may seriously injure or destroy desirable plantings. Selectivity is relative; exceed the recommended

CLASSIFICATION OF HERBICIDES USED IN TURF (BASED ON USE)*

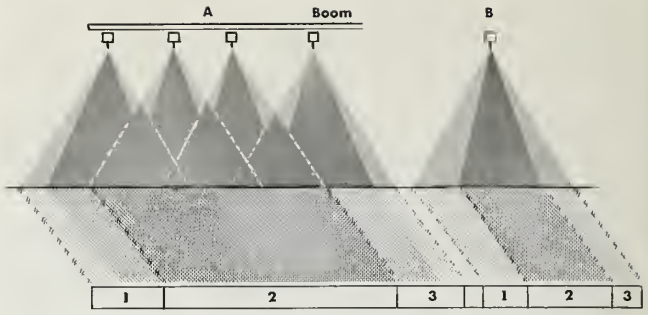
	Selective use			Non-selective use			
	Foliage applied		Soil applied	Foliage applied		Soil fumig.	Soil applied
	Contact	Trans.		Contact	Trans.		
1 AMA (Amine methanearsonate)		×					
2 Amitrole					×		
3 Ammonium methylarsonate		×					
4 Benefin (Balan ®)			×				
5 Bensulide (Betasan ®)			×				
6 Cacodylic acid				×			
7 Calcium arsenate			×				
8 Calcium cyanamide							×
9 CMA (calcium methanearsonate)		×					
10 Dalapon (Dowpon ®)		×			×		
11 Dazomet (DMTT ®, Mylone ®)						×	
12 DCPA (Dacthal ®)			×				
13 Dicamba (Banvel ®)		×	×				×
14 Diphenamid (Dymid ®, Enide ®)			×				×
15 DSMA (disodium methanearsonate)		×					
16 MAA (methearsonic acid)	×			×			
17 MAMA (monoammonium methanearsonate)		×					
18 Mecoprop (MCPP)		×			×		
19 Metham (Vapam ®, VPM ®)						×	
20 Methyl bromide						×	
21 Monuron			×				×
22 MSMA (monosodium acid methanearsonate)		×					
23 Neburon (Scotts Bonus for Dichondra)			×				×
24 Paraquat				×			
25 Silvex (2,4,5-TP)		×			×		
26 TCA (trichloroacetic acid)							×
27 Terbutol (Azak ®)			×				
28 2,4-D		×			×		
29 Weed oil				×			

* This listing is to illustrate a classification of available herbicides based on uses made of them. It does not necessarily constitute a recommendation of their use by the University of California.

A knapsack-type sprayer is excellent for smaller areas that must be sprayed.

application rate and selectivity may be lost. Insufficient application rates usually result in failures or incomplete weed control. Makeshift spray equipment should not be depended upon to apply herbicides accurately.

Spray rig pressures should be kept at a minimum, generally 30 psi (pounds per square inch) or less, to prevent drift and confine the herbicide to the immediate target area to be treated. The higher the pressure applied at the nozzles the smaller the spray droplet size. Small droplets remain airborne and can move or drift over great distances. Damage from spray drift onto susceptible ornamentals can be disappointing and costly. All herbicide spraying, or the application of granular types should be done under calm air conditions to reduce drift.



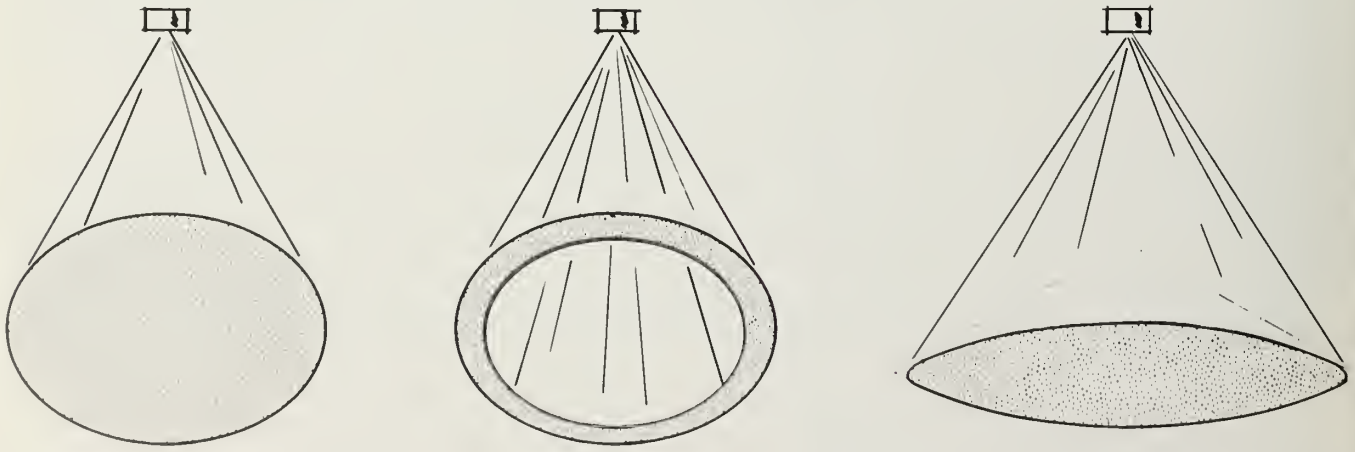
Flat fan nozzles spaced at proper intervals (A) and boom height adjusted to provide double coverage for uniform application rate (zone 2). Each parallel spray swath should be overlapped to cover zones 1 and 3 at end of boom. The same procedure should be used when covering small areas with a single flat-iron nozzle (B).

Applying herbicides uniformly

Application rates are usually given as a certain weight (dry formulations) or volume (liquid formulations) per acre or per 1,000 square feet. Such recommendations assume that every square foot of ground or turf covered will receive a uniform amount. On extensive turf areas, such as parks and golf courses, this is accomplished most effectively with a powered sprayer equipped with evenly spaced nozzles on a boom. Nearly all weed control spraying is done with nozzles that produce a flat-fan spray pattern.

When applying spray by hand on a small area, walk at a uniform speed and stop to pump up the sprayer as soon as a change in the spray pattern is noticed. If the pressure is allowed to drop too far, the spray swath will be more narrow and less material will be applied. Avoid hesitating to apply extra spray on clumps of weeds, keep moving at a constant speed over every square foot, whether you see weeds or not. Occasionally shake the tank vigorously to maintain a uniform mixture if you are applying a wettable powder or an emulsifiable formulation.

Some companies market granular herbicides—often formulated with fertilizer—that can be applied uniformly di-



Types of spray patterns available with different nozzles: Solid cone on left; hollow cone in center, flat spray on right. An even distribution of the material over the area being treated is necessary at all times.

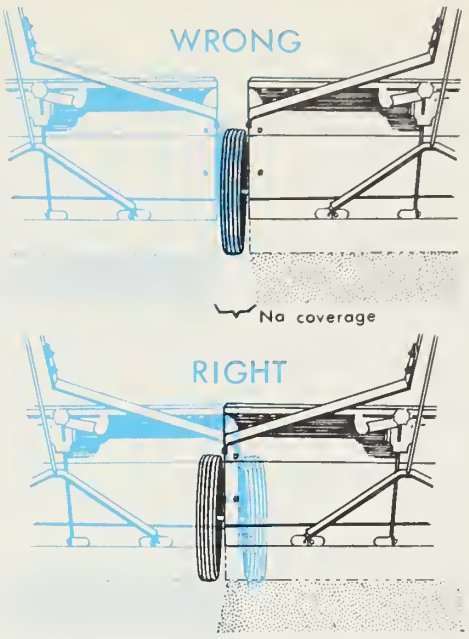
Do not use 2,4-D, silvex, MCPP, or dicamba in sprayers used to apply insecticides or fungicides to ornamentals. Very small amounts remaining, even after several washings, can injure or kill ornamentals.

rectly from the package with a lawn spreader. This is a convenient way of applying herbicides uniformly over a small area. Granular formulations are more expensive per pound of active herbicide, however. Whether applying a herbicide wet or dry, more uniform applications can usually be obtained by applying one-half of the required herbicide over the entire area in one direction (say north and south) and then completing the application with the remaining half over the area in the opposite direction, in this case, east and west.

Spot spraying with herbicides

Applying herbicides to individual weeds is probably the most useful method employed on very small plots. This is done by mixing a foliage-applied herbicide, such as 2,4-D, with water at the recommended concentration and applying a short burst of spray while holding the nozzle directly above the weed. Apply just enough spray to thoroughly wet the leaves—but no more! Excessive drenching can kill the turfgrass in the sprayed spot. Stoloniferous turf grasses, particularly bentgrass and bermudagrass, are particularly susceptible to abusive spot treatments of silvex and to a lesser degree of 2,4-D. Unless the weeds are widely scattered it would be safer and very little more expense involved to spray larger areas with equipment that provides more uniform application precision.

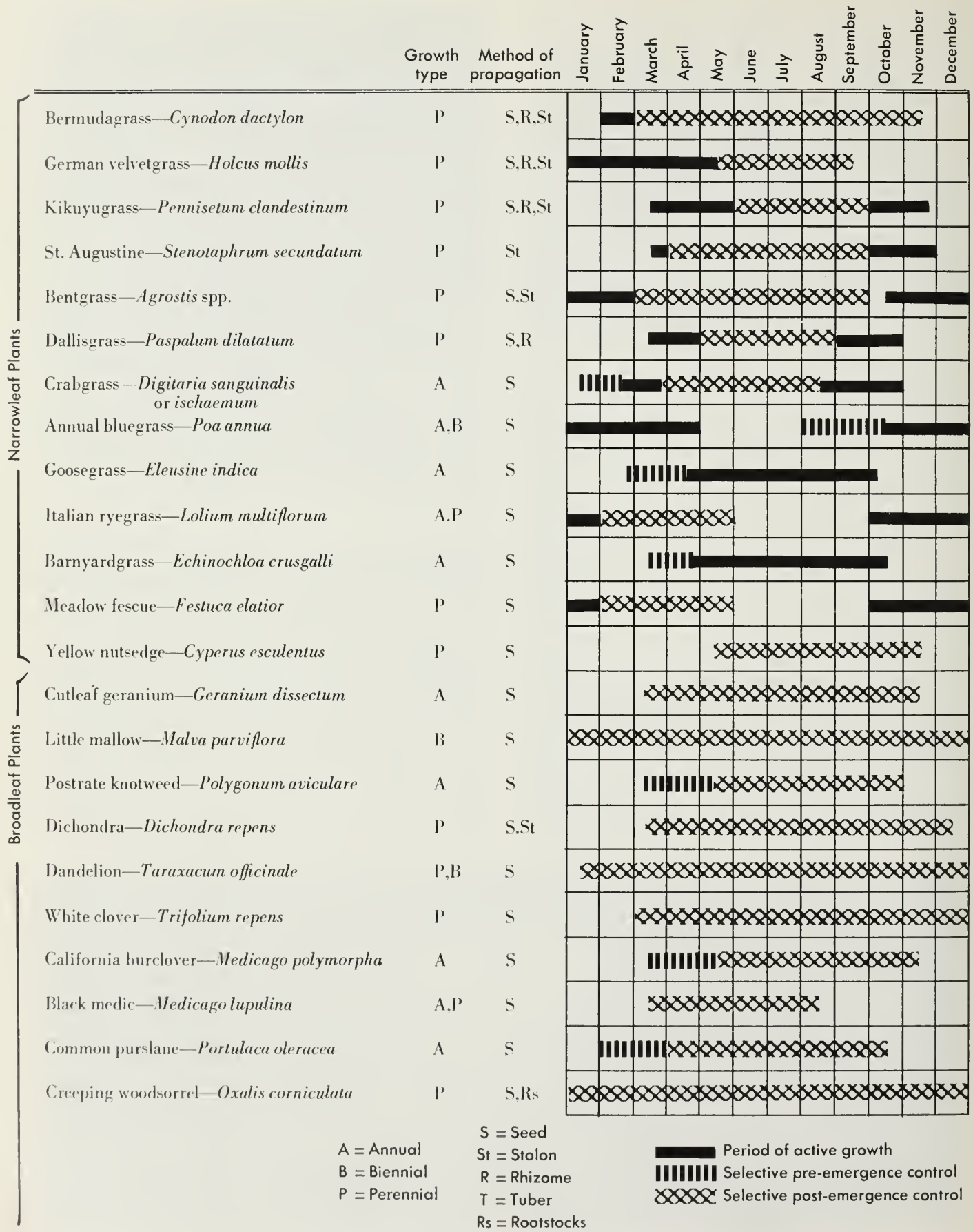
Spot treatments are useful in applying nonselective, foliage-applied herbicide applications. The application of dalapon for the control of individual clumps of tall fescue, ryegrass, or bermudagrass in grass turf is an example. Excessive drenching of spots with dalapon will result in soil contamination and the destruction of the turf grasses. Use a very low pressure to minimize excessive dalapon application. Localized applications of dalapon sprays to trim back



When using this type of applicator, bands of chemical must overlap slightly to avoid missed areas.

grass around flush sprinkler heads, in sidewalk cracks, and along lawn edges can be useful. If excessive dalapon is applied around sprinklers the herbicide may be washed out of the immediate target area with devastating results when the sprinklers are used. (See photo below.)

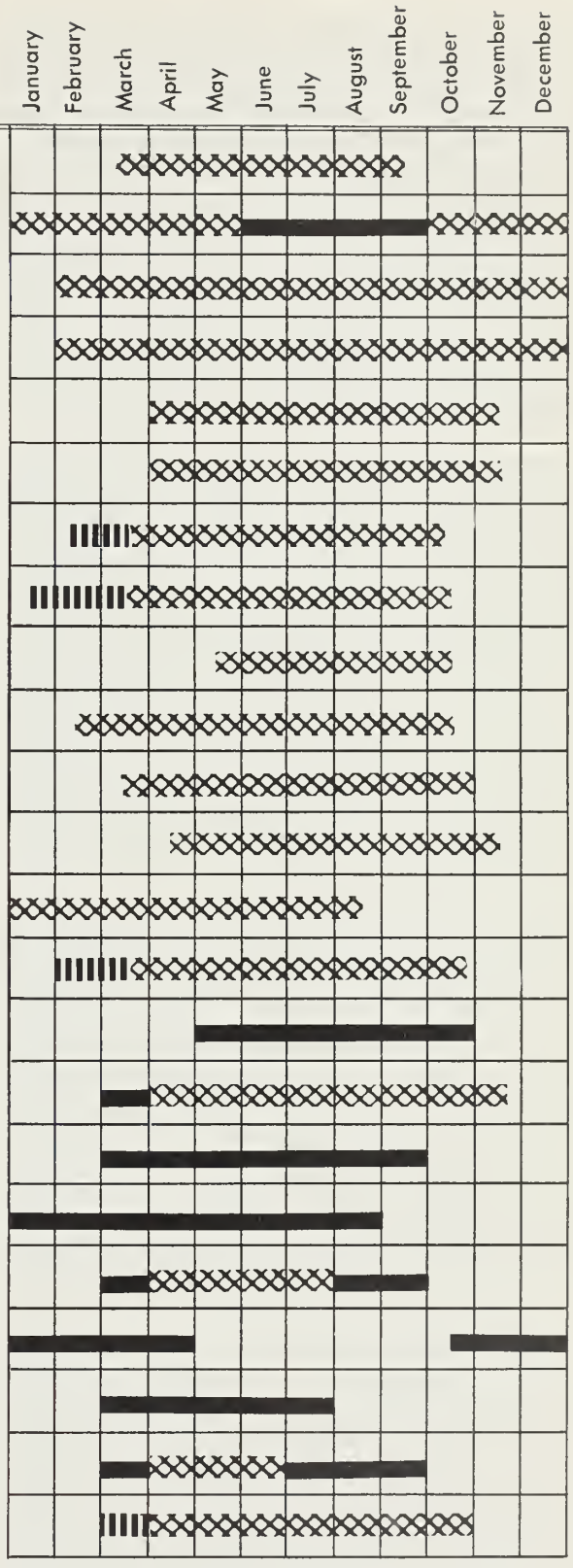
Spot treatments with dalapon for weedy grass control or with 2,4-D for broadleaf weeds can be accomplished in either grass or dichondra turf by using a paintbrush, or by fixing a small rag or sponge on the end of a stick and daubing the individual weeds. Use the same herbicide and wetting agent concentration in water as recommended for spray applications. This application technique is useful in killing dandelions in dichondra with 2,4-D. Dichondra is quite sensitive to broadleaf weed herbicides such as 2,4-D. Some herbicides are packaged in convenient ready-to-use aerosol spray cans for spot applications in home turf.


Growth type
Method of propagation
January
February
March
April
May
June
July
August
September
October
November
December
Narrowleaf Plants
Broadleaf Plants
Bermudagrass—Cynodon dactylon P S,R,St
German velvetgrass—Holcus mollis P S,R,St
Kikuyugrass—Pennisetum clandestinum P S,R,St
St. Augustine—Stenotaphrum secundatum P St
Bentgrass—Agrostis spp. P S,St
Dallisgrass—Paspalum dilatatum P S,R
Crabgrass—Digitaria sanguinalis or ischaemum A S
Annual bluegrass—Poa annua A,B S
Goosegrass—Eleusine indica A S
Italian ryegrass—Lolium multiflorum A,P S
Barnyardgrass—Echinochloa crusgalli A S
Meadow fescue—Festuca elatior P S
Yellow nutsedge—Cyperus esculentus P S
Cutleaf geranium—Geranium dissectum A S
Little mallow—Malva parviflora B S
Postrate knotweed—Polygonum aviculare A S
Dichondra—Dichondra repens P S,St
Dandelion—Taraxacum officinale P,B S
White clover—Trifolium repens P S
California burclover—Medicago polymorpha A S
Black medic—Medicago lupulina A,P S
Common purslane—Portulaca oleracea A S
Creeping woodsorrel—Oxalis corniculata P S,Rs
A = Annual
B = Biennial
P = Perennial
S = Seed
St = Stolon
R = Rhizome
T = Tuber
Rs = Rootstocks
Period of active growth
Selective pre-emergence control
Selective post-emergence control

Broadleaf Plants

Broadleaf Plants *Continued*

	Growth type	Method of propagation
Pennywort—*Hydrocotyle umbellata*	P	S,Rs
Scarlet pimpernel—*Anagallis arvensis*	A	S
Curly dock—*Rumex crispus*	P	S
Red sorrel—*Rumex acetosella*	P	S
Buckhorn plantain—*Plantago lanceolata*	P	S
Broadleaf plantain—*Plantago lanceolata*	P	S
Mouseear chickweed—*Cerastium vulgatum*	A.P	S,Rs
Chickweed—*Stellaria media*	A	S
Birdseye pearlwort—*Sagina procumbens*	P	S
Birdseye speedwell—*Veronica persica*	A	S
English daisy—*Bellis perennis*	P	S
Field bindweed—*Convolvulus arvensis*	P	S,R
Soliva—*Soliva sessilis*	A	S
Spotted spurge—*Euphorbia maculata*	A	S
Spotted catsear—*Hypochoeris radicata*	P	S
Healall—*Prunella vulgaris*	P	S,Rs
Henbit—*Lamium amplexicaule*	A	S
Field madder—*Sherardia arvensis*	A	S
Yarrow—*Achillea millefolium*	P	S,Rs
Southern Brass buttons—*Cotula australis*	A	S
Wartcress—*Coronopus didymus*	A	S
Prickly lettuce—*Lactuca scariola*	A	S
Cudweed—*Gnaphalium chilense*	A.B	S



A = Annual
B = Biennial
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Rs = Rootstocks

Period of active growth
Selective pre-emergence control
Selective post-emergence control

BERMUDAGRASS

Cynodon dactylon (L.) Pers.

Perennial; with rhizomes and stolons. Stolons (runners) many jointed and rooting at the nodes. The stems are smooth, and wiry. Fine leaves pointed at end, with conspicuous tuft of hair at base. Does not grow well in shade. Seedheads somewhat similar to crabgrass. A common turfgrass in Southern and Central California.

GERMAN VELVETGRASS

Holcus mollis L.

Perennial; with vigorous slender rhizomes; leaves velvety, appearing somewhat grayish in color. Purplish lines at base of stems common. Shows up as light velvety clumps in turf.

KIKUYUGRASS

Pennisetum clandestinum Hochst.

Perennial; with vigorous, thick rhizomes and stolons. Seeding very sparse, not conspicuous. Mowing stimulates seed production. Leaves pointed on ends; similar to Bermudagrass, except coarser, wiry. Often mistaken for St. Augustine grass. Found in south and central coastal counties.

ST. AUGUSTINE GRASS

Stenotaphrum secundatum (Walt.) Kuntze

Creeping perennial; thick flattened stolons, spreading leaves that have a boat shaped leaf tip. Flower shoots 4 to 12 inches tall. Leaves and stems smooth and hairless. Sometimes used as a turfgrass.

BENTGRASS

Agrostis spp.

Perennial; fine bladed, spreading by seed and stolons. Roots easily and forms stems at every node. Develops dense sod patches, normally much finer than other turf. Commonly used as a turfgrass.

DALLISGRASS

Paspalum dilatatum Poir.

Perennial; bunch type growth, leafy at the base. Rhizomes very closely jointed appearing almost scaly. Seed heads sparsely branched on long stems.

LARGE CRABGRASS

(HAIRY CRABGRASS)

Digitaria sanguinalis (L.) Scop.

Annual; spreading by seed and to minor extent by rooting from lower swollen nodes of stems. Low bunching leafy grass with larger, hairier leaves than smooth crabgrass. Light green to yellowish green in color. Frequently heavy in overwatered turf.

SMOOTH CRABGRASS

Digitaria ischaemum (Schreb.) Muhl.

Annual; similar to hairy crabgrass except the leaves and leaf sheaths are smooth. Leaves longer, narrower than hairy crabgrass. (Shown here in dichondra.)

ANNUAL BLUEGRASS

Poa annua L.

Annual; tufted, light green, forming mats when allowed to mature without cutting. Stems flattened with short, smooth leaf blades. Will continue to form seed under extremely close mowing. May root at the lower nodes. Usually found in cool, often watered areas.

GOOSEGRASS

Eleusine indica (L.) Gaertn.

Annual; low rosette, mat forming, stems compressed. Appears as silvery, pale green clump. Flower stalks, short, stout, and compressed. Seed heads similar to dallisgrass except short and stiff. Normally found in compacted areas or areas of heavy wear. Produces seed even under close mowing.

ITALIAN RYEGRASS

Lolium multiflorum Lam.

Annual or short lived perennial; robust plant with long, narrow, glossy leaf. Spikes long with spikelets attached on alternate sides. Can be readily noticed in lawns by glossy appearance. Forms clumps. Often used in inexpensive lawn seed mixtures.

BARNYARDGRASS

Echinochloa crusgalli (L.) Beauv.

Annual; stout stems, branching at base, forms mats or clumps when mowed. Leaves smooth with prominent midrib. Seed heads a panicle with seeds the size of millet (or bird seed). Found normally in poorly managed turf of low fertility. Commonly called "watergrass."

TALL FESCUE

Festuca arundinacea Schreb.

Perennial; forming clumps with upright leaves. Leaf blades wide, coarse with rasp-like margins, radiating from a central clump. Flower stocks tend to lie flat while mowing resulting in ragged appearing turf. Used for turf in playgrounds and parks. Meadow fescue, *Festuca elatior* L. has similar clumping characteristics; included in some seed mixtures.

WILD BARLEY

(Common Foxtail)

Hordeum leporinum Link

Annual grass occurring as clumps principally in newly seeded turf. The leaves are smooth, dull green. Seedheads, squirrel or foxtail-shaped, often remaining after mowing.

CUTLEAF GERANIUM

Geranium dissectum L.

Annual; freely branched, remains prostrate in turf. Leaves are dissected into narrow leaf divisions. Conspicuous small purple flowers.

LITTLE MALLOW

(CHEESEWEED)

Malva parviflora L.

Annual or very often a biennial; stems somewhat low spreading. Leaves roundish, broad with a red spot at base of the blade. Normally found in poorly managed or new turf.

DICHONDRA

(*Dichondra donnelliana* Tharp. & Johnst.)

Perennial; low, creeping habit. roots freely at nodes and forms dense mats. Leaves are kidney-shaped and from ¼ to 1½ inches in width. Flowers inconspicuous.

DANDELION

Taraxacum officinale Weber

Perennial that is stemless, basal leaves, flower stalks arising from the base. Conspicuous yellow flowers. At maturity the flower becomes a white fluffy ball of a seed head. This plant grows from a single brownish taproot.

WHITE CLOVER

Trifolium repens L.

Perennial; low growing, rooting at the nodes, white, sometimes pinkish flowers. Trifoliate leaf with white crescent-shaped mark.

BLACK MEDIC

Medicago lupulina L.

Annual or sometimes perennial. The stems are 4-angled, hairy, and branched at the base. The branches are prostrate and spreading. Flowers are small, yellow, in long dense heads.

CALIFORNIA BURCLOVER

Medicago polynorpha L.

Annual; smooth prostrate stems. Leaflets have whitish and red spots scattered over the surface when young. The small flowers are yellow. Seed pod or "bur" is twisted spirally with spiny protrusions. Stipules at base of leaflets deeply divided.

CREEPING WOODSORREL

(YELLOW OXALIS)

Oxalis corniculata L.

Perennial; with running rootstocks. Prefers shade. Leaves appear to be similar to clover, green or reddish color with sour taste. Flowers small, yellow.

YELLOW NUTSEDGE

Cyperus esculentus L.

Perennial spreading by seeds and tubers. Appears similar to grass except for triangular stems. Nutsedge also has three tiers of leaves whereas grasses have two tiers. leaves shiny dark green, stiff, upright—grows faster than turfgrasses. Underground tubers are formed from the scaly stolons. Nutlets have almond taste.

COMMON PURSLANE

Portulaca oleracea L.

Annual, prostrate, fleshy stems, flowers pale yellow. Leaves fleshy, succulent.

SCARLET PIMPERNEL

Anagallis arvensis L.

Annual; low growing, branched with 4-angled stems. Leaves opposite or in whorls of three. Flowers are salmon colored about ¼–⅓ inch in diameter, opening only under a clear sky.

BROADLEAF PLANTAIN

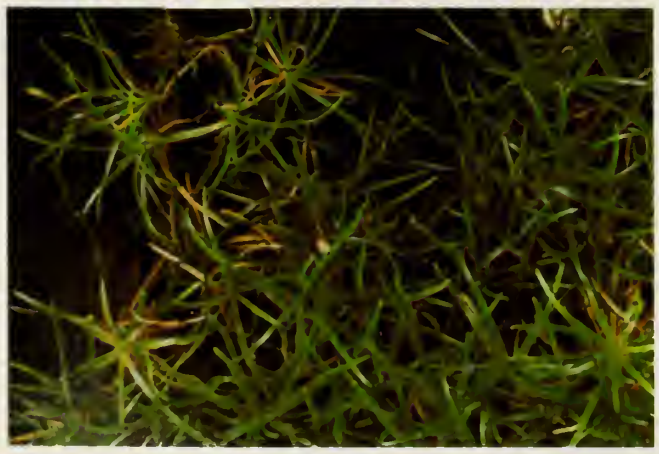
Plantago major L.

Perennial; leaves large 3–6 inches long, smooth. Conspicuous flower stalks 3–6 inches in length. Roots fibrous and shallow. May be distinguished from buckhorn plantain by the broader leaf and shorter flower stalks.

BUCKHORN PLANTAIN

Plantago lanceolata L.

Perennial; long narrow leaves with parallel veins, 3–12 inches in length, slightly hairy, brownish hairs surround the base of leaves. Growth habit similar to broadleaf plantain. Long seed stalks, much longer than leaves.



BIRDSEYE PEARLWORT

Sagina procumbens L.

Perennial; stems prostrate forming mats, rooting at the nodes, found in coastal areas. Looks like moss.

CHICKWEED

Stellaria media (L.) Vill.

Annual; slender much branched stems with a line of white hairs along on one side. Leaves smooth and pointed. Grows in cool weather or in winter in sheltered area.

CURLY DOCK

Rumex crispus L.

Perennial; growing from a large brownish taproot. Normally found as a rosette in turf but will attain a height of 2 to 3 feet. Leaves are large, reddish-green in color, curly and wavy along the margins.

RED SORREL

(SHEEP SORREL)

Rumex acetosella L.

Perennial; similar to curly dock, leaves are arrow shaped. Roots are a slender running rootstock, reddish in color.

PENNYWORT

Hydrocotyle umbellata L.

Perennial; creeping, rooting at nodes of slender rootstocks. Troublesome in southern California. Round leaves approximately ½ inch in diameter with wavy margin. Can be distinguished from dichondra by wavy leaf margins.

BIRDSEYE SPEEDWELL
(BYZANTINE SPEEDWELL)
Veronica persica Poir.

Annual; stems 4″ to 16″ tall, leaves roundish or oval. Small deep blue flower with white center on stalks ⅜″ to 1″ long. Plants covered with hairs.

ENGLISH DAISY
Bellis perennis L.

Perennial; low growing, with oval basal leaves. Prominent upright flower stalks throughout season with showy white or pinkish daisy-like flowers.

FIELD BINDWEED
Convolvulus arvensis L.

Perennial; deep rooted, prostrate or twining stems with arrow shaped leaves. Flowers conspicuous white or pink. Plant can take many forms and shapes.

SOLIVA
Soliva sessilis R.&P.

Annual; small plant with dissected leaves. Foliage covered with fine hairs. When seed has formed it appears as a small 3-spined bur which can be readily felt when pressing a clump with your hand.

SPOTTED SPURGE

Euphorbia maculata L.

Annual; grows prostrate on ground, stems forming circular mats from single taproot, non-rooting at the nodes; aggressive—milky sap in leaves—may be green or reddish but easily identified by red spot on upper center of leaflet.

PROSTRATE KNOTWEED

Polygonum aviculare L.

Annual; grows prostrate forming circular mats; found in hard worn turf areas of high traffic. slender wiry stems, non-rooting, at the nodes, leaves bluish-green and smooth, no purple spotting as found on spotted spurge; white inconspicuous flowers.

MOUSEEAR CHICKWEED

Cerastium vulgatum L.

Perennial; sticky-hairy leaves and stems, leaves rounded on end: prostrate, forming dense patches. Small white inconspicuous flowers.

SPOTTED CATSEAR

HAIRY CATSEAR

Hypochoeris radicata L.

Perennial; with thick fleshy taproot, normally found as a rosette in turf. Leaves lobed or saw-toothed with coarse yellow hairs on both upper and lower surfaces. Flower yellow, may have several flowers from each stem.

HEALALL
(SELFHEAL)
Prunella vulgaris L.

Perennial; gray, hairy or smooth green plant, with spreading root-stocks. Usually found in patches. Also a silvery, hairy form.

HENBIT
Lamium amplexicaule L.

Annual; several upright 4-angled stems that root at the lower nodes, rounded coarsely toothed leaves are whorled up the stem. Irregular purple flower, the lower lips of the flower spotted. Difficult to control.

SOUTHERN BRASS BUTTONS
(AUSTRALIAN BRASS BUTTONS)
Cotula australis (Sieber) Hook. f.

Annual; strong scented, low growing. Looks similar to soliva or wart-cress. Has small, yellow flowers, leaves deeply toothed and covered with fine hairs.

FIELD MADDER
Sherardia arvensis L.

Annual; with slender, square, hairy stems. Low growing, forming mats. Leaves in whorls, strong odor. Flowers small, blue, pinkish in clumps at ends of the stems.

COMMON YARROW

Achillea millefolium L.

Perennial; plants hairy, with spreading rootstocks. Leaves somewhat like a carrot. Flowers white or yellow in dense flat clusters at the end of stems. Flowers are not normally found in turf.

CARPET WEED

Mollugo verticillata L.

Annual, with whorls of leaves on many branched stems 4 to 6 inches in length. Mat forming. Leaves about ½ inch long with 5 to 6 in a whorl around the stem. Inconspicuous white flowers on short stalk at each joint of the stem appearing in May to November. Somewhat similar to four-leaved all-seed.

WART-CRESS

Coronopus didymus (L.) Sm.

Annual; low growing, strong smelling, looks very similar to *Soliva*. Seeds are borne in two lobed wrinkled pods.

LOW AMARANTH

Amaranthus deflexus

A low, prostrate annual with the end of the stem turning upward. Stems 1–1½ feet long. Leaves short petioled, oval, ¼ to 1 inch long and about ½ inch broad. Flowers inconspicuous, in dense clusters at the ends of the stem, appearing from May to November. Another pigweed, prostrate pigweed, is very similar except it forms a small dense mat.

WHITESTEM FILAREE

Erodium moschatum (L.) L'Hér

Annual; with leaves forming a low rosette. Stems generally whitish. leaves up to 10 inches in length with several toothed leaflets. Flowers small purple-bluish. Seed pods form a storksbill.

BRISTLY MALLOW

Modiola caroliniana (L.) G. Don.

A low perennial, with spreading stems, 6–18 inches long. Leaves round with coarse-cut margins 1 to 1½ inches across, may look similar to cut-leaved geranium. Flowers dull red, round, less than ½ inch in size in summer. May be found almost throughout California.

BRISTLY OXTONGUE

Picris echioides L.

A coarse, rough biennial, 4 to 6 inches tall in turf. Leaves 2 to 6 inches in length, ½ to 1½ inches wide, rough-hairy on upper and lower surfaces. Flower heads yellow about ½ inch broad occurring in clusters near the top of the stem. Flowers appear from June to December.

COTTON BATTING PLANT (CUDWEED)

Gnaphalium chilense Spreng.

Annual or biennial; white silk-hairy plant; leaves long, narrow, rounded at tip on base and more pointed at top of plant. Small inconspicuous flowers in clusters.

INSECT and RELATED PESTS of TURFGRASS

Andrew S. Deal, R. N. Jefferson, and F. S. Morishita

This section tells how to identify insects and related pests, either by inspection of the pest or the damage it causes, and gives recommendations for the types of treatment that should be applied. Because the information on chemicals to use changes very rapidly, actual recommendations for chemicals should be obtained from the leaflet "Guide to Turfgrass Pest Control," revised annually and available at the office of your local University of California Farm Advisor.

Make regular inspections

Regular inspections of lawn areas are very important if injury from insect pests is to be avoided. Insects may cause such disorders as die-back, stunting or distortion of growth, browning, yellowing, or bleaching of leaves. If such symptoms are noted, action should be taken rapidly because insect populations can build up in a very short period of time if conditions are right. Some pests feed only at night and unless a special effort is made to look for them they may go undetected for some time.

Identifying the trouble

Some of the symptoms of trouble discussed above may be caused by disease, unfavorable soil conditions, or poor cultural practices, and these possibilities should be investigated before pest control measures are taken. In fact, the first line of defense against turfgrass pests is a program of good cultural practices; poorly kept turf shows pest injury sooner and recovers more slowly than vigorous, well-kept turf. Regular thatch removal and aeration discourages insect pests and aids in penetration with sprays if and when treatment is needed.

One method used in detecting the presence of insect pests of lawns is the "pyrethrum test." Mix one tablespoon of one of the commercial garden insecticides containing 1 to 2 per cent pyrethrins in one gallon of water. Mark off one square yard of lawn area, including some damaged and some undamaged grass, and apply the entire gallon of mixture as evenly as possible to that area with a sprinkling can. Pyrethrum is very irritating to many insects and will bring them to the surface within ten minutes where they may be seen. Insects which may be detected in this way are cutworms, sod webworms, lucerne moth larvae, skipper larvae, and vegetable weevil larvae.

White grubs or the larvae of billbugs will not respond to the pyrethrum test, but may be found, if present, by carefully digging around the roots of the grass. In heavy infestations the grass roots will be eaten away and the grass can be rolled back like a carpet. If an average of more than five cutworms, 10 skipper larvae or 15 sod webworms per square yard, or more than one white grub or billbug larva per square foot of established lawn area are found, control measures should be taken.

Leafhoppers, scale insects, leaf bugs, spider mites, and flea beetles can be found, if present, by carefully examining the leaves, stems and crowns of the grasses or dichondra.

In large lawn areas, such as parks, golf courses and memorial parks, the pyrethrum test or other inspections for pests should be made at several locations in order to determine the extent of the infestation. In some cases the problem may be localized and treatment of the entire area may not be necessary.

Accurate identification of insects in lawns is important because many insects may be found that are not pests at all, and thus control measures will not be necessary. Also, different pests require different chemical treatments and application methods, for effective control.

Application of insecticides

Lawns to be treated to control most pests that feed on the leaves, stems, and crowns of the plants should first be irrigated well. As soon as the plants have dried the insecticide should be applied and further irrigation withheld until necessary to prevent wilting. This allows the insecticide to remain on the plants for the longest possible period and thus increases the effectiveness of the treatment.

When lawns are to be treated for pests that feed below ground on the roots, such as white grubs, or the larvae of billbugs, the treatment should be applied and then followed with a heavy irrigation to carry the insecticide into the soil. *Do not apply insecticides to dichondra needing water or when the temperature is above 90°F.*

In general, sprays are preferred to other methods of application for the control of turfgrass and dichondra pests. Granular formulations are also suitable for control of white grubs, billbugs, chinch bugs, cutworms, skipper larvae, sod webworms, and slugs and snails.

Most of the insecticide dosages given in the "Guide" refer to the amount of active ingredient needed per 1000 square feet of lawn area. This can be applied in any convenient amount of water provided enough is used to thoroughly wet the grass or dichondra down to the ground. Most operators use about 20 gallons of spray per 1000 square feet. For control of spider mites greater volume may be required and the dosage is given in terms of the amount of *formulated material* per 100 gallons of diluted spray. (See section on calculations.)

TURFGRASS AND DICHONDRA PESTS

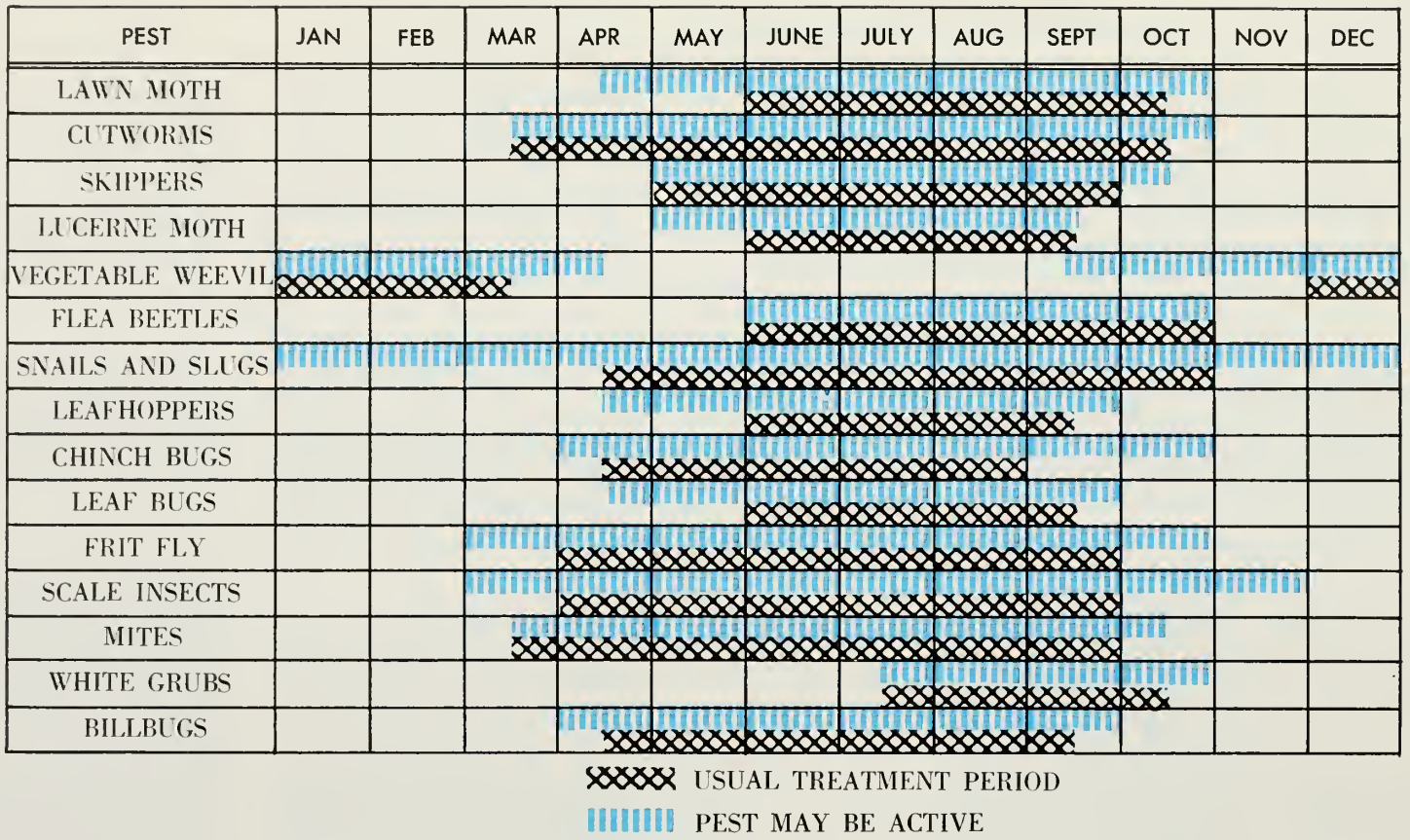
Pest and Description	Life History and Habits	Susceptible Plants	Damage Caused	Method of Detection
Lawn moths (Sod webworms), *Crambus sperryellus* Klots and *C. bonifatellus* (Hulst.). Larvae slender, grayish, black-spotted caterpillars about ¾ inch long when full grown, rather sluggish in their activity. Moths whitish or buff-colored. Wing span slightly over 1 inch. *C. sperryellus* with white or silver stripe along margin of forewing, *C. bonifatellus* without stripe. Wings folded close to body when at rest giving slender appearance.	Moths hide during day in grass and shrubbery, fly over grass at dusk. Eggs are laid on the leaves and crown. Larvae hatch in a few days and begin to feed. They feed at night and hide during the day in shelters constructed of bits of grass and debris. Moths begin flying in April or May in warm areas and breeding continues through October. There may be 3 or 4 generations per year with broods overlapping.	All grasses. Bent and blue grasses most susceptible to injury, especially new lawns. Dichondra is not attacked.	Larvae feed on grass blades, growing tips and greener portions of crown, but not on the roots. Damaged areas appear as scattered irregular, brown patches in turf.	Pyrethrum test. Treat when 15 or more worms are found per square yard. Preventive treatments are suggested for newly planted lawns.
Cutworms, *Pseudaletia unipuncta* (Haw.). *Feltia subterranea* (Fab.), *Peridroma saucia.* (Hübner), *Agrotis ipsilon* (Hufn.). Thick-bodied caterpillars from one to two inches long when full grown. Usually dull-colored, greenish, gray, brown or blackish; often with spots or longitudinal stripes. Adults are night-flying moths, dull or somber colored and with a wing span of 1¼ to 1½ inches.	Moths fly at night and lay eggs on leaves of grasses, dichondra, or nearby plants. Larvae feed at night and hide in holes, under debris, or in mat of organic matter at the surface of the ground during the day. Breeding continues throughout the warm months of the year and there may be several generations per season with overlapping broods.	All grasses. Dichondra.	Cutworms feed on the leaves and crown and may cut off plants near the soil line. Only the larvae are injurious.	Pyrethrum test. Treat when 5 or more cutworms are found per square yard.
Skippers, *Hylephia phylaeus Drury* (Fiery skipper). Larvae about 1 inch long, and brownish-yellow in color. First 2 body segments behind head smaller than rest, giving appearance of a "neck." Adults are small butterflies with wing span of a little more than 1 inch. Males have orange-yellow wings spotted with black; wings of the female are dark brown, with orange-yellow spots.	Female butterflies lay eggs on turfgrass leaves as well as on other ornamental plants during the warm months. Adults feed on nectar from various flowers. Lantana is a favorite. There may be several generations per year.	All grasses, especially bentgrasses. Dichondra not usually attacked.	Larvae feed on leaves and crown.	Pyrethrum test. Treat when 10 or more larvae are found per square yard.
Lucerne moth, *Nomophila noctuella* (D. and S.). Larvae are slender, spotted caterpillars similar in appearance to lawn moth larvae, but larger. Full-grown caterpillars about 1 inch long with tendency to wriggle actively when disturbed. Adults are moths with wing span of an inch or slightly more. Hind wings gray, forewings mottled gray-brown, with two pairs of indistinct dark spots.	Moths fly at night and females lay eggs on clover and other legumes as well as turfgrasses and dichondra. Activity is greatest during the warm months of the year.	All grasses. Clovers. Dichondra.	Damage is to the leaves and stems.	Pyrethrum test.
Vegetable weevil, *Listroderes costirostris obliquus* (Klug). Larvae are small, green, legless grubs about ⅜ of an inch long when fully grown. Adults are brownish or grayish weevils or "snout" beetles about ⅜ of an inch long. Wing covers are very rough or punctate with sparse, short setae or hairs. Each wing cover has a short, pointed protuberance on the top near the back end. The adults do not fly. Both larvae and adults are very slow and sluggish in movement.	Vegetable weevils are active only during the winter and spring months. No males are present and females produce young without mating. Both adults and larvae feed at night. Occasional adults can be seen during the day, but usually hide among plant foliage or in other dark places. Larvae hide in the soil beneath the plants during the day.	Dichondra.	Damage first appears as small holes in the leaves, but in the case of heavy infestations the leaves may be skeletonized or completely removed leaving only the bare stems. Since the adults do not fly, infestation of new areas usually takes place very slowly and damage is usually localized or spotty.	Pyrethrum test. Adult beetles often crawl to nearby lights at night.

Pest and Description	Life History and Habits	Susceptible Plants	Damage Caused	Method of Detection
Flea beetles, *Chaetocnema magnipunctata* Gentner. Adult flea beetles are black and very small, about 1 millimeter (1/25 inch) long. The larvae live in the soil and are not usually seen.	Little is known of the life cycle of this flea beetle. Adults appear to be active from May through October in warm areas. Observations indicate that one generation is completed in about a month. The larvae are thought to develop on the roots of plants. Adult beetles jump readily when disturbed—hence the name "flea beetle."	Dichondra.	Adult flea beetles feed on the upper surfaces and skeletonize the leaves. When enough of the leaf is eaten away the leaf turns brown. Injury may be localized or spotty and damaged areas are often assumed to have been caused by lack of water or fertilizer burn.	Close inspection of infested dichondra will reveal the small shiny, black beetles sitting on the leaves. Moving the open palm of the hand lightly over the surface of the plants will cause the beetles to jump about and some will light on the back of the hand or arm and can thus be readily seen.
Snails and Slugs. Shiny mollusks with or without protective shells.	Slugs and snails move on a slime trail and are more active under moist conditions. They hide under vegetation or in dark places during the day and come out to feed at night.	Dichondra.	Damage is frequently more severe near flower beds, ground cover areas, shrubbery or planter boxes where the slugs and snails hide during the day. Prolonged feeding in these areas may leave only bare stems or completely kill out the dichondra plants.	Look for the slime trails which appear shiny in the sunlight. Slugs and snails may also be seen in the evening or at night with the aid of a flashlight as they move onto lawn areas from daytime hiding places. Light sprinkling of suspected infested areas activates these pests and aids in detection.
Leafhoppers, *Draeculacephala minerva* Ball, *Deltacephalus sonorus* Ball and others. Small active insects 1/8 to 1/4 inch long. Adults whitish green, yellow or brownish-gray. May be speckled or mottled. Adults fly or jump short distances when disturbed. Nymphs are various colors as adults, but without wings. Nymphs have characteristic habit of moving sideways or backwards when disturbed.	Adult females insert eggs into tissues of the host plant. Eggs hatch in a few days in warm areas. Several generations may occur in a season.	All grasses.	Both adults and nymphs suck juices from the leaves and stems of grasses. Symptoms are a bleaching or drying out of the grass.	Examine areas in the lawn which look bleached or dry, also the surrounding green areas. Look closely for the small, wedge-shaped, jumping or flying adults as you walk. Also look closely on the leaves and stems for the nymphs which move sideways or backwards when disturbed.
Southern chinch bug, *Blissus insularis* Barber. Adults are about 1/5 inch long, black with nearly all white wings which are folded flat over the body. There are both long- and short-winged forms. The young are bright red but turn black as they approach the adult stage.	There appear to be at least two generations a year, with all stages present in any month. The highest populations occur during the summer and at this time development from egg to adult takes about 6 weeks.	Only St. Augustine grass is seriously damaged.	Yellowish to brownish patches in lawn.	Close examination of damaged and adjacent areas.
Leaf bugs, fleahoppers, etc. (Family Miridae). A common one is the fleahopper, *Spanogonicus albofasciatus* (Reut.) Adults are about 1/8 inch long, blackish or grayish with white markings on the wings which are folded flat over the back.	Little is known about the life cycle on turfgrasses, but several generations per season are thought to occur in warm areas. Fleahoppers jump readily or fly short distances when disturbed.	All grasses. Dichondra.	Both adult and nymphs suck juices from leaves and stems of grasses or dichondra. When infestations are heavy, growth is retarded and the grass may die in spots.	Look for fleahoppers by running the open palm of the hand lightly over the grass. If these insects are present, they can be seen hopping about. Some may hop onto the back of the hand or onto curbs or sidewalks where they are easily seen.

TURFGRASS AND DICHONDRA PESTS

Pest and Description	Life History and Habits	Susceptible Plants	Damage Caused	Method of Detection
Frit fly, *Oscinella frit* (L.). Adult frit flies are slightly more than 1/16 inch long, shining black with small yellow markings on the legs. The eggs are pure white, 1/32 inch long, with a finely ridged surface. Mature larvae are 1/8 inch long, yellow, with black, curved mouth hooks. Pupae are yellow at first, then turn dark brown and are slightly less than 1/8 inch long.	The winter is passed in the larval stage in the stems of grasses. Pupation takes place in the spring and the first adults emerge about March. Eggs are laid on the leaves and leaf sheaths of grasses. Several larvae may occur in one plant. There are at least three broods, the activity of the last extending into October in warmer areas.	All grasses. Bent and bluegrasses are most susceptible to injury.	The larvae tunnel in the stems near the surface of the soil causing the upper portion of the plants to turn brown and die. Damage is most common on golf greens. Injury appears first on the collars of greens and moves in toward the center. The high or upper sections are usually the first to show the symptoms. Greens with high organic matter content appear to be most susceptible.	Look for small, black adult flies hovering close to the grass from mid to late morning. Look for the larvae in the stems near the ground level. A hand lens or dissecting microscope is useful in finding the very small larvae.
Bermudagrass scale, *Odonaspis ruthae* Kot., adults are about 1/16 inch long and are covered with a whitish, clam-shaped shield.	Bermudagrass scale infests bermudagrasses commonly in southern California. It occurs primarily on the stems, but may also be on leaves. It is most likely to occur in lawn areas shaded by trees or buildings and is favored by the development of a heavy thatch.	Bermudagrasses.	Bermudagrass scales suck juices from the plants. Heavily infested grass takes on a brown, dry appearance and new growth is retarded.	Close examination of infested grass will reveal a whitish material on the stems and crown which give it a "moldy" appearance. Even closer examination with a hand lense or microscope will reveal the clam-shaped shields of the scale insects.
Rhodesgrass scale, *Antoninia graminis* Mask., adults are about 1/16 inch in diameter, globular, dark purplish-brown in color, and with a white cottony covering.	Rhodesgrass scale infests bermudagrass and St. Augustine grass. This insect is established at several locations in southern California. It is not yet known how severe the damage from this pest may be.	Bermudagrasses. St. Augustinegrass.	Rhodesgrass scale also sucks juices from the plant and reduces growth and vigor.	Rhodesgrass scale is detected in the same manner as bermudagrass scale—by close examination of the grass.
Spider mites of the Family Tetranychidae are about 1/50 inch long, globular in shape and reddish, yellowish, or greenish in color. The two-spotted mite has a pronounced dark spot on each side of the body.	Spider mites lay eggs on grasses, dichondra, oxalis or other plants in lawns. Some species spin fine webbing which may entirely cover the grass in spots, especially in protected areas near curbs, walls or planter boxes. Spider mites breed throughout the warm months of the year producing several generations per season.	All grasses Dichondra Clovers Oxalis.	Mites feed by puncturing the leaves and sucking out the juices. First symptoms of this injury appear as a speckling or stippling of the leaves. This is followed by a yellowing, bronzing, or bleaching and drying of the leaves.	Close examination of the leaves for stippling, speckling, yellowing, bronzing, bleaching, drying, webbing, plus the presence of mites and mite eggs. (A hand lens or low power microscope may be necessary to see the mites and eggs.)
The clover mite, *Bryobia praetiosa* Koch is about 1/30 inch in length with long front legs. Its body is somewhat depressed and is reddish-brown to greenish in color. The legs are amber to orange colored.				
The oxalis mite is bright red and is approximately the size of the two-spotted spider mite, but with conspicuously longer legs.		The oxalis mite lives on oxalis only.	This mite sucks out the juices and turns the oxalis white.	

Pest and Description	Life History and Habits	Susceptible Plants	Damage Caused	Method of Dctection
Bermudagrass Mite, *Aceria neocynodonis* Keifer. Extremely small (can barely be seen with a 10× hand lens), white, worm-like mites. Has two pairs of legs near head end. Females lay spherical, transparent eggs singly or in groups. Also called Eriophyid mite.	Little is known of the life history of this pest, but it is thought to overwinter beneath the leaf sheaths in the crowns of the bermndagrass plants. The females begin laying eggs beneath the leaf sheaths of the new growth in the spring. Breeding continues dnring the warm part of the year and several generations occur during the season. The mites snck juices from the stems and inside of the leaf sheaths.	Common and hybrid bermndagrasses.	Shortening of stem internodes resulting in a stunted, rosetted or tnfted appearance of the plants. With heavy infestations the grass tnrns brown and dies. When infestations are allowed to persist the grass may be thinned ont allowing the growth of weeds.	Look for plants with a stunted, rosetted, or tufted appearancc. Pull lcaf sheaths away from stems. Examinc inside of lcaf sheaths and exposed stems with 10× to 20× hand lens or dissecting microscope. Look for mites and spherical, transparent eggs.
White grubs, *Cyclocephala* sp. Larvae or grnbs about 1 to 1½ inches long when fully grown, C-shaped when at rest with many folds or wrinkles in front half of body. Rear end of body often slightly larger in diameter than rest and may be bluish or blackish in color. White grnbs have a brown head capsule and three pair of conspicuons legs. (Grubs of the billbug and vegetable weevil, described elsewhere in this handbook, are legless.) Adnlts of white grubs are commonly called May beetles, June beetles, or June bngs. They are a little over one-half inch long and yellowish-brown with a reddish head.	The common species of white grubs attacking tnrf in California have a one-year life cycle. The larvae approach matnrity about October. The adults emerge from the ground in late May and in June. Little feeding appears to take place during the winter or early spring.	All grasses. Bermnda and rye are the most snsceptible.	White grubs feed beneath the soil snrface on the roots of grasses. Aboveground symptoms are a tnrning brown and dying of the grass in localized spots or in large irregnlar-shaped areas. Where infestations are heavy, the grass roots may be entirely eaten away and the turf may be rolled back like a carpet. Damage is usually most severe in September and October when the grubs are reaching maturity and the growth of bermudagrasses is slowing down.	Examine the soil around the grass roots. Dig in brown areas near the edge of green, healthy areas of grass. If more than 1 grub per sqnare foot of area is found the lawn shonld be treated.
Billbugs, *Sphenophorus phoeniciensis* Chitt. and *S. venatus vestitus* (Chitt.). The larvae of billbngs are white, legless grubs from ¼ to ⅜ of an inch long when fnll-grown. The adnlts are small, black or brown weevils, or "snout" beetles.	Little is known of the billbug life history in California. Adults can be found throughout the year and in many areas larvae can also be found.	All grasses, but mainly bermndagrass. Old lawns in warm inland areas most susceptible.	Billbug larvae or grnbs feed beneath the ground on the roots of grasses. Aboveground symptoms are turning brown and dying of grass in spots or sometimes large areas.	Examine the soil around the grass roots. Dig in the edges of brown areas near green healthy grass. If more than 1 grub per square foot is found, the lawn should be treated.



*NOTE: The periods of pest activity indicated in the calendar are only approximate. Actual pest appearance will vary from area to area and even in the same areas from year to year depending upon temperature, rainfall and other factors, both physical and biological.

Treatment periods indicated are also only approximate. In most cases insecticides should be applied only when pests are present in sufficient numbers to cause damage. An exception to this rule is the application of preventive treatments for control of lawn moths in newly planted lawns.

Lawn moth larva

Lawn moth adult

Flea beetle damage to dichondra (leaves greatly enlarged)

Frit fly adults (millimeter scale in background)

Billbug pupa (left) and legless larvae

Billbug injury to turf (trowel shows comparative size)

Legless larva of vegetable weevil

Adult vegetable weevil

NEMATODE DISEASES of TURFGRASS

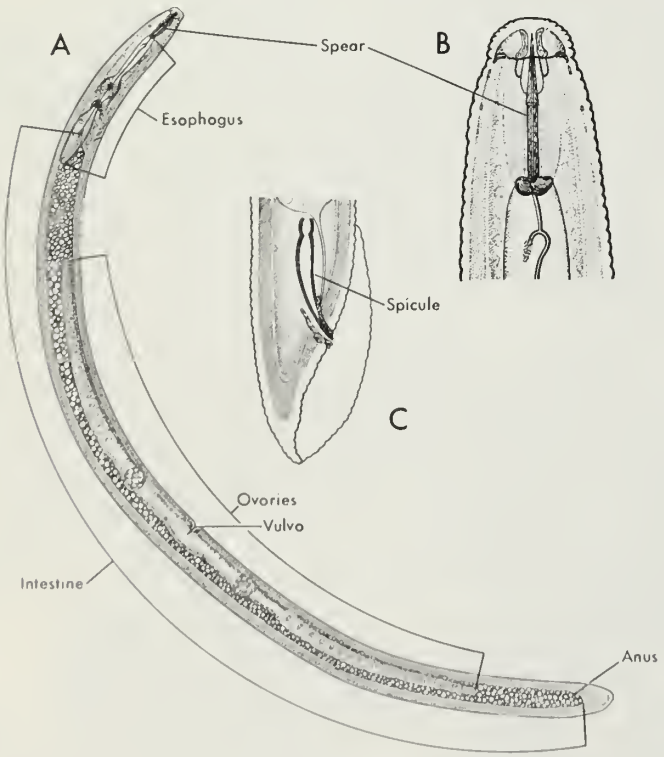
John D. Radewald

Disease is one of the most limiting factors in turfgrass production in California. A plant disease is defined as "a continuous abnormality which in some way interferes with structure, function, or economic value of a plant." Many parasitic and nonparasitic agents may cause plant diseases. A parasite is a living organism that obtains its food from another living organism. A parasite is not necessarily a pathogen (a cause of disease).

The recognized parasites that may cause plant diseases are: higher plants (mistletoe, dodder, broomrape), insects, nematodes, fungi, bacteria, and viruses. Frequently two or more pathogens act simultaneously on a plant and are referred to as "disease complexes."

The *association* or finding of any one of these potential parasitic disease-causing organisms, including nematodes, with the root system of a given turf plant *does not prove* that the turf is diseased and the nematode is the pathogen. The only thing that is *proven* by these associations is that a possible turf disease does, or eventually may, occur, depending upon the *host*, the *parasite* (in this case, the nematode), and *environment*. "Guilt by association" means finding nematodes in soil around the roots of a turf plant and immediately concluding they are causing a turf disease. Whether the nematode is causing a disease or not *must* be proven by reliable methods of experimentation. *Only* when this experimental proof is obtained does proof of *pathogenicity* of the nematode on the turf exist.

Nematological research on turfgrass has produced a large number of reports from the United States and other parts of the world on nematode associations with roots of turf species. These reports are of value as they establish a basis on which more detailed work may establish the true importance of a given nematode on a given turfgrass species. Unfortunately, only a very few associations between a nematode and a specific turfgrass have been studied in enough detail to actually prove that a nematode does cause a disease to a given turf species. Some species of nematodes are injurious to turf in other parts of the United States but these nematodes are not known to occur on turf in California. Therefore, the turf grower in California has little information on which to base a decision with regards to a nematode control program. However, investigations on this problem are underway.



A Adult Female Nematode (actual length of Nematode is 1/30 inch)
B Enlargement of Head
C Enlargement of Male Tail

What is a nematode?

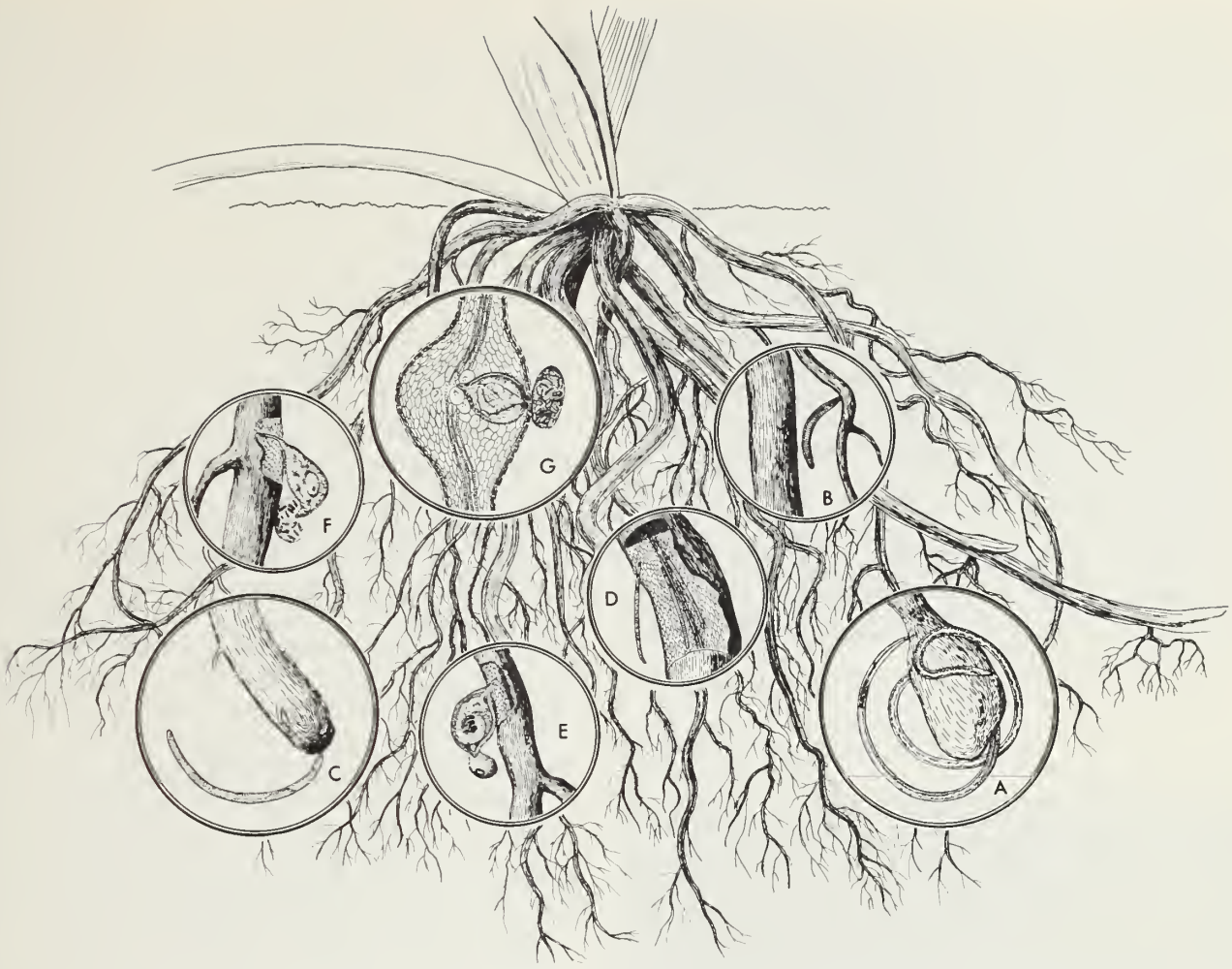
Nematodes are roundworms, sometimes called eelworms, or nemas. Most plant-parasitic nematodes are microscopic in size and can only be identified by a trained technician with the aid of specialized equipment.

A nematode feeds by inserting the hollow spear (stylet) into the plant cells and sucks out the cellular contents. Some nematodes inject substances into the plant before they feed. The esophagus contains a pumping mechanism that aids in the ingestion of plant cell contents, and glands that produce digestive materials. The gut is a simple tube that terminates at the anus.

A nematode feeds by inserting the hollow spear (stylet) into the plant cells and withdraws the cellular contents. Some nematodes inject substances into the plant before they feed. The esophagus contains a median bulb that aids in the ingestion of plant cell contents, and glands that produce digestive materials. The gut is a simple tube that terminates at the anus.

The female nematode lays eggs either singly or in egg masses, depending on the species. A single female of some nematodes may lay 500 eggs or more. Plant-parasitic nematodes, being obligate parasites, *can* complete their life cycles when the roots or other portions of a susceptible host plant are present for them to feed upon.

The life histories, feeding habits, and methods of reproduction of nematodes vary. Some nematodes are migratory



Life histories of nematode parasites of turf: A—Dagger nematode; B—Ring nematode; C—Stubby root nematode; D—Lesion nematode; E—Cyst nematode; F—Reniform nematode; G—Root-knot nematode.

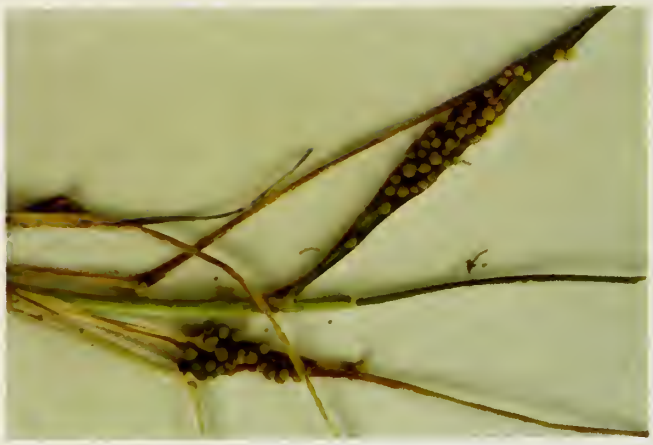
and feed strictly from the outside of the plant tissues (ectoparasites). They deposit their eggs singly *in the soil*. Other nematodes, such as the lesion nematode, are migratory and feed with their bodies situated either outside the root tissues or within the roots, and deposit their eggs singly *in the soil or within the root*. Still other nematodes only migrate as young and become sedentary as adults. Their bodies may be located exterior to the root, partially embedded within the root, or completely embedded. These nematodes lay their eggs in egg masses in the soil. The eggs are surrounded by a gelatinous matrix. The egg mass of the root-knot nematode may be found within the root tissue with the adult female or protruding from the root tissue into the soil. The female cyst nematode usually does not deposit her eggs outside the body wall, but retains them within her body. When the female dies, the body wall forms a leathery cyst that protects the eggs from adverse environmental conditions until they hatch.

The location of the nematode, and its eggs, or young (i.e., within the root, or outside the root in the soil) is important when considering the application of a chemical to control nematodes on *established* turf. Nematodes and eggs located within the root tissues are protected from exposure to the chemicals that are drenched or injected into the soil and unless the nematocide is a systemic one, eggs and animals located within the root tissues will escape.

Nematode larvae shed their skins (molt) four times. After the last molt, the nematode is an adult. It varies in shape from the typical worm to the spherical female. The time required for nematodes to complete a life cycle, from egg to adult, varies. Under optimum conditions most plant-parasitic nematodes complete this cycle in from 3 to 6 weeks. The life cycle may be extended to several months during periods of high or low temperatures, drought, and where poor hosts exist.

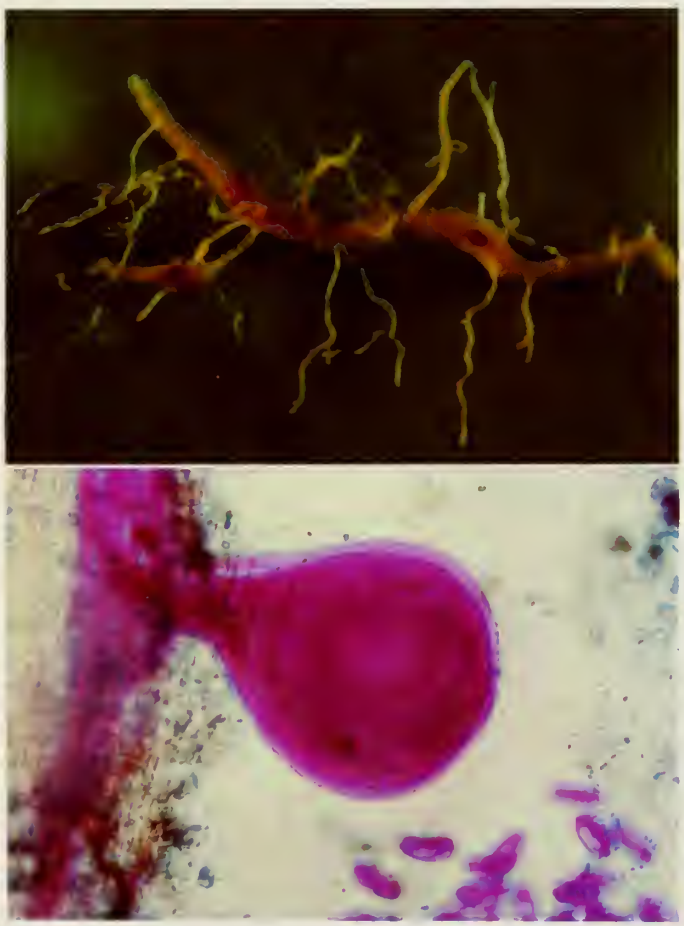
Parts of turf plants attacked

Nematodes are known to attack and damage most of the parts of turf plants. Some nematodes destroy the seed, others attack the stems and leaves. The most frequently attacked portions of turf plants are the roots. There are *no* aboveground symptoms which are completely diagnostic



Leaf galls on *Poa annua* incited by *Anguina* sp.

The root-knot nematode (*Meloidogyne naasi*) on Seaside bent grass. Lower—microphoto of root-knot female after the root tissues have been cut away from her body but with the head still located in the vascular region of the root.



for nematode damage to turf roots. Nematode-diseased plants may appear stunted, chlorotic (yellowed), and generally unthrifty. They also may wilt prematurely during the warmer periods of the day due to the lack of an adequate root system to supply the plant with water. The symptoms on the roots vary, depending upon the nematode species. The most easily recognized nematode symptom on roots are the galls caused by the root-knot nematode. These swellings or galls are visible to the naked eye. The root-knot nematode is of great economic importance in California to vegetable, field, and deciduous crops, and is commonly found on dichondra (figure 5). In 1965, a new root-knot species, *Meloidogyne naasi*, was described. This nematode, found in two areas in California, is a proven pathogen of turfgrasses. Contrary to most root-knot species, *M. naasi* seems to prefer grasses to other hosts.

The lesion nematode, *Pratylenchus* sp., is often found associated with turfgrasses, but we have no proof that it is pathogenic to turfgrasses in California. On other hosts the symptoms are root lesions of variable sizes and shapes.

Other nematodes, such as the stubby root nematode, attack only the growing root tips and stop their elongation. These root tips may appear swollen, discolored, or both, and growth of lateral roots is pronounced on some hosts. This nematode is commonly found around turf roots, but its importance on turf species in California is questionable. Other nematodes commonly found in association with turfgrasses in California include the ring nematode (*Criconemoides* sp.), the dagger nematode (*Xiphinema* sp.) and the pin nematode (*Paratylenchus* sp.). Their detrimental effects to turf have not been studied in enough detail to determine their economic importance to California turf species.

Detecting plant-parasitic nematodes

The only way to detect a potential nematode disease of turf roots is by proper processing of soil and root samples. A sample should consist of several soil cores, an inch or two in diameter and 6 to 8 inches in depth, taken in the area where the suspected nematode problem exists. Submit the turf roots with the soil. Place all soil cores from the suspected disease area in a single plastic bag and seal to prevent drying. Take similar samples in adjacent turf areas that appear normal, so that a comparison of nematodes found in the two areas can be made. Label the bags containing the samples so that the identity of each individual sample can be maintained. Keep the samples cool and transport them to a diagnostic laboratory as soon as possible, preferably the same day the samples are taken. Remember that *samples should be kept cool* and *not allowed to dry* as most nematodes are extremely sensitive to high temperatures and drying.

Your local farm advisor can give you a list of commercial laboratories in California that provide nematode detection and identification service. These laboratories will usually provide a quantitative measure of the plant parasitic genera in each sample submitted.

Control

The potential methods for control of plant-pathogenic nematodes that may affect turfgrasses are similar to those used for the control of these pests on most other crops.

Quarantine. Nematodes move very slowly in soil, possibly only a foot or two per year under their own power. Man is the major disseminator of nematodes. In a turf nursery or landscaped area, nematodes are easily spread by cultivation, watering operations, and transfer of contaminated plants within the landscape area. The first precaution, therefore, is to avoid introducing nematodes into areas that are free of plant-parasitic nematodes. The turf grower may employ a "self-imposed" quarantine to avoid introducing nematode-infested soil of rootings into areas free of the pest. This self-imposed quarantine by the turf grower, landscape gardener, or homeowner is the simplest and most economical means of controlling potential nematode problems, providing the land is free of the pest.

Preplant control measures. If barren soil in which a turf nursery is to be established, or soil around a newly constructed home, is found infested with nematodes known to be pathogenic to turf, a preplant nematode control program may be used. The compounds listed in Leaflet 209 will control nematodes, and some will control other potential pests, including weeds, fungi, bacteria, and insects. When considering the large investment required for establishing a turfgrass nursery or turf around a home, it is apparent that the most practical approach would be to control *all* potential pests possible before the desired plant species are introduced, even though the initial cost may be higher. The labor costs for weeding alone, as an example, in a newly established turfgrass nursery or home lawn can easily offset the initial costs of a broad spectrum biocide such as those listed in Leaflet 209. If nematodes are the only concern of the grower, a specific nematocide may be used for a lesser cost than that of the broad spectrum biocides.

The root-knot nematode (*M. incognita*) on dichondra.

Postplant control measures

Some states make postplant recommendations for the control of various nematode diseases of turf. However, research data in California is not complete and no University recommendations can be made for postplant turf treatments for nematode control. If nematodes are detected in an established turf and the grower wishes to attempt a postplant control program, small areas may be treated with registered chemicals and compared with nontreated areas for plant response and actual nematode control. The local Farm Advisor, the Extension nematology specialists, and Experiment Station nematologists can suggest compounds for control measures and provide assistance in evaluating the experimental treatments.

DISEASES of TURFGRASS

Arthur H. McCain, Robert M. Endo, and Robert D. Raabe

Most of the serious diseases of turfgrass in California result from infection by microscopic fungi. Fungi are low forms of plant life which are threadlike and are incapable of manufacturing their own food but live off dead or living plant or animal matter. Most fungi produce spores (seed-like units) or other resistant forms, *e.g.*, sclerotia, which may be spread by wind, water, mechanically as by mowers, or infected plant material such as grass clippings.

Spores, sclerotia, and threads require moisture and a favorable temperature to form new threads which grow over the surfaces of the plant or in it and cause infection. Because of this, diseases of grasses are most common during rainy seasons, or when irrigation moisture remains on the leaves for long periods. Watering during early morning is better than late evening watering; deep, infrequent watering is better than shallow frequent watering. Some diseases are favored by warm temperatures while others are destructive during the cooler months of the year.

Most diseases of turfgrasses are easier to prevent than to cure. To minimize the possibility of disease, plant the right kinds of grasses for the particular climatic zone; weakened, nonadapted grasses are susceptible to certain turf-attacking fungi, and to such stresses as drought and hot, dry winds.

Recommended cultural practices such as mowing, fertilization, irrigation, aerification, etc., will help prevent diseases by mantaining a vigorously growing turf. A properly maintained turf generally is less severely damaged by diseases and is able to make a quicker recovery than one which is poorly maintained.

One cultural practice that is closely tied to disease prevention is fertilization—specfically the amount of nitrogen applied. Too much nitrogen can result in soft, lush growth of the grass—a condition favorable to some diseases. On the other hand, turf that does not have enough nitrogen applied to it will be susceptible to certain other diseases.

When disease control cannot be obtained by cultural methods, certain fungicides are effective and their use is recommended. Fungicides are usually most effective if applied before the disease becomes severe. If a disease does become severe it generally requires a higher rate and more frequent fungicide applications.

Every year new and frequently improved products are made available. Therefore specific fungicides are not mentioned here. Recommendations for chemical control of specific turfgrass diseases can be obtained from the University of California Farm Advisor in your area. Ask for Leaflet 209.

Brown patch

Symptoms. Areas of turf affected with brown patch consist of irregular brown areas which may range from several inches to many feet in diameter. Centers of the spots may recover, resulting in rings of diseased grass. Leaves and leaf sheaths turn olive-green, wilt, become light brown, and die. Stems, crowns, and roots also may be infected. In light attacks, roots and crowns usually are not involved and plants recover. All lawn grasses are susceptible.

Cause. Brown patch is caused by the soil-inhabiting fungus, *Rhizoctonia solani* and other *Rhizoctonia* species. The fungi are active as fine threads (hyphae) that survive in the soil or in and on the turf. Resting structures (sclerotia) composed of hard masses of fungus threads are resistant to adverse conditions and difficult to control with fungicides.

The disease is favored by excess thatch and mat, high temperatures, (75 to 90°F) high humidity, and soft, lush growth due to excess nitrogen. Disease in the summer months is more common in warm, inland areas. A cold-weather (40 to 60°F) form of the disease occurs infrequently.

Control. Reduce shading and improve soil aeration and water drainage. Water when needed to a depth of 4 to 6 inches if possible. Check this with a soil probe since water may not be penetrating due to excess turf debris, unfavorable soil type, or to too rapid application of water. Avoid excessive nitrogen fertilization that results in soft growth foliage.

Fungicides are more effective when used in preventive applications but also will stop the disease in progress.

Dollar spot

Symptoms. Small, circular areas of turf about 2 inches in diameter are affected. Spots may merge to form large, irregular areas. Leaves are water-soaked at first, later turn brown and finally straw-colored. Fine, white, cobwebby fungus threads which may be seen in early morning are responsible for spread.

Cause. *Sclerotinia homeocarpa*, a fungus which survives in the soil by means of sclerotia, is the causal agent.

Disease is common near or on the coast, especially on bentgrass.

Moderate temperatures, (60 to 80°F) and excess moisture, excess mat and thatch favor dollar spot. Turf deficient in nitrogen tends to develop more dollar spot than turf adequately fertilized.

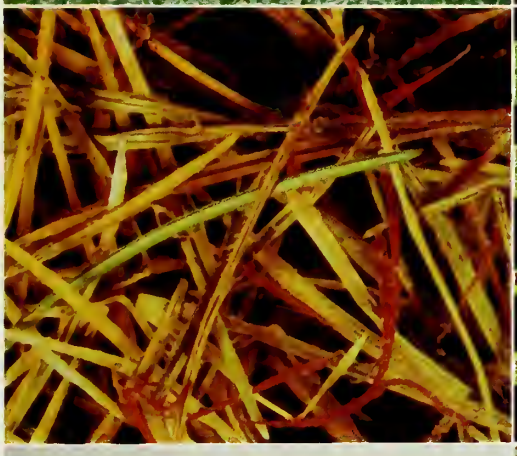
Brown patch. Pencil for comparison of size

Dollar spot. Silver dollar for size

Fusarium patch in bentgrass

Melting out on Kentucky bluegrass

Closeup of red thread



Rust spores on grass blades

Stripe smut on bluegrass

Typical symptoms of fairy ring

Control. Keep thatch at a minimum. Water only when needed to a depth of 4 to 6 inches. Apply adequate nitrogen.

It is usually necessary to use fungicides to control this disease, especially on closely clipped grass. The fungicides are most effective if applied prior to disease development in the early spring and fall.

Fusarium patch

Symptoms. This disease appears as roughly circular, dead patches of 1 to 2 inches, up to 12 inches in diameter. Leaves first become water-soaked, turn reddish-brown, then bleached. Minute, white or pinkish, gelatinous spore masses occasionally are seen on dead leaves. Fungus threads, also white or pinkish, may be seen in early morning. The disease is common on *Poa annua* and bluegrass. Ryegrass, bentgrasses and fescues are also susceptible.

Cause. The fungus, *Fusarium nivale*, probably survives the hot dry summer months as resistant hyphae. Cool, (32 to 60°F) moist conditions, such as prolonged rainy periods in winter, favor the disease, which usually appears first on shaded plants.

The disease is common in northern and central California in winter but is rare in southern California.

Control. Reduce shade, improve soil aeration and water drainage. Avoid excess nitrogen fertilization especially in the fall of the year.

Mercury-containing fungicides are effective but must be applied in the fall prior to the occurrence of symptoms.

Melting out (on bluegrass)

Symptoms. Circular to elongate, purplish or brownish spots with straw-colored or brown centers occur on leaf blades, leaf sheaths, and stems. Leaf spots are general, indicating spread by wind-borne spores. Crown and roots frequently are attacked. Crown-infected plants are weakened and frequently die if irrigated during hot, dry, windy weather, resulting in a thinning-out of the turf in scattered areas.

Although common Kentucky bluegrass is very susceptible, there are a number of improved varieties that are resistant.

Cause. Melting out is caused by *Helminthosporium vagans* which probably survives in infected plants or debris as fungus threads and as spores. It also may be seed-borne.

Cool, (50 to 70°F), moist conditions favor the disease which first appears on shaded plants and is most severe on closely-clipped turf. This disease is common in the wet winter months, especially in coastal northern and central California.

Control. Reduce shade, improve soil aeration and water drainage. Do not mow grass lower than 1½ inches. Several fungicides are helpful in controlling melting out if applied when the disease first appears. It is important to reduce crown infections which are responsible for the death of plants.

Melting out (on other than bluegrass)

Melting out of bentgrasses, fescues, ryegrass, and bermudas is caused by *H. sorokinianum*. The symptoms are similar to melting out caused by *H. vagans*, except leaf spots usually show brown rather than straw-colored centers, and borders of spots are purplish to dark brown.

Warm temperatures (70 to 90°F), dew, and high humidity favor the disease which first appears on plants growing in shaded areas. It is most damaging on closely clipped turf, especially in the spring and summer in southern California. Plants die of crown infection, usually during hot, dry, windy weather. Control is the same as for *H. vagans*. Mow grass at recommended heights.

Leaf blotch (bermudagrasses)

Symptoms. Tiny, purplish to reddish spots occur on leaf blades and leaf sheaths. Seedlings are very susceptible but plants rapidly become resistant. Affected seedlings wither, turn brown and die. Roots and crown may develop small lesions. Only bermudagrasses are susceptible.

Cause. The fungus *H. cynodontis* is similar to *H. vagans* and *H. sorokinianum*. It probably survives in infected bermudagrass plants and debris as hyphae and as spores, though it may be seedborne.

Control. Leaf blotch damages young seedlings or adult plants that have been weakened by excess thatch, deficient nitrogen, and unfavorable growing conditions. Remove thatch at regular intervals. Apply adequate nitrogen.

Loose smut

Symptoms. In this disease of common bermudagrass, the flower heads are replaced by masses of dark spores.

Cause. The fungus, *Ustilago cynodontis*, remains in infected plants the year around. Spores infect germinating seeds and young stolons but show symptoms principally at flowering. The disease is most prevalent in warm weather and under conditions that promote flowering.

Control. Keep grass growing vigorously and remove flower heads by mowing before spores are produced.

Because fungus spores may cling to seeds or occur in soil, seed treatment with suitable fungicides will prevent infection from seed-borne or soil-borne spores.

Stripe smut

Symptoms. Infected plants are often pale green and stunted, and long black stripes consisting of spore pustules of the fungus occur in the leaves. Infected leaves curl, become shredded, and die.

The disease is favored by moderate temperatures and is prevalent in the spring and fall. Infected plants may die in hot, dry weather. Although common on some bluegrass varieties, bentgrasses also are susceptible.

Cause. Spores of *Ustilago striiformis* from the leaves frequently contaminate the seed; germinating spores may infect seedlings and young tillers. The fungus stays in the diseased plants from year to year.

Control. Some resistant bluegrass varieties have been developed. Seed treatment with selected fungicides will control the seed-borne phase. A systemic fungicide is available.

Red thread

Symptoms. Turf is usually affected in patches 2 to 15 inches in diameter, but the disease may be general over large areas. Pink webs of fungal threads bind leaves together and pink, gelatinous fungal crusts, $\frac{1}{4}$- to $\frac{3}{4}$-inch long, projecting from leaves may be seen. Plants usually are not killed.

Bentgrasses, bluegrasses, fescues and ryegrasses are susceptible.

Cause. Red thread is caused by *Corticium fuciforme* which overseasons as pink or red, gelatinous crusts of fungal threads. Disease occurs commonly along the coast of northern and central California; is rare in southern California.

Red thread usually appears on plants deficient in nitrogen, and during periods of prolonged cool, wet weather.

Control. Apply adequate nitrogen and reduce shading. Fungicides, especially those containing cadmium, if applied at the earliest stages of the disease will prevent further development.

Grease spot

The turf is killed in small roughly circular spots (2–6 inches) which tend to run together. Blackened leaf blades wither rapidly and turn reddish-brown. Leaf blades tend to lie flat, stick together, and appear greasy. Roots may be stunted and brown, especially the tips.

All turf grasses are subject to attack by the fungi that cause grease spot.

Cause. The fungi that cause grease spot are called water molds because excess free water, which is essential for their development, also may weaken the plants, favoring severe disease development.

Several species of *Pythium* may be involved, especially *P. aphanidermatum*. The causal fungi produce thick-walled, sexual spores which survive for long periods in the soil.

Because the fungus depends on excessive free moisture, grease spot usually appears in low spots that remain wet. *P. aphanidermatum* can spread very rapidly at high temperatures (80 to 95°F) and cause severe damage; other species of *Pythium* may cause damage during cool weather.

Control. Reduce shading, improve soil aeration and water drainage. Water, when needed, to a depth of 4 to 6 inches. Several fungicides are available.

Rust

Symptoms. Elongate, reddish-brown to orange pustules containing spores appear on the stems, leaves, and leaf sheaths. Reddish-brown to orange spores adhere to fingers when pustules are rubbed. Some bluegrass varieties are particularly susceptible, though ryegrass is commonly infected.

Cause. *Puccinia striiformis* and *P. graminis* overseason in infected grasses. The airborne spores may be carried long distances. Moderately warm, moist weather favors rust development. Condensed moisture, even of dew, for 10 to 12 hours is sufficient for spores to infect plants.

Control. Keep plants growing rapidly by fertilization and irrigation. Most of the infected portions of leaves are removed by mowing and the spores trapped inside the mowed leaves die out rapidly. Fungicides containing oxycarboxin are particularly effective in controlling rust.

Fairy ring

Symptoms. A dark green band of turf develops in a circle or semicircle; mushrooms may or may not be present. Frequently, just behind the dark green band is an area of sparse, brown, dying grass, caused by lack of water penetration. Weed invasion is common. All turf grasses can be affected by fairy ring, but the effects may be less on grass species with long stolons.

Cause. Several species of mushrooms cause fairy rings. In northern and central California the predominant fungus is *Marasmius oreades;* in southern California species of *Lepiota*.

Fairy ring develops most frequently in soil high in undecomposed thatch, the fungi living primarily on the thatch.

Control. Apply adequate nitrogen. Remove thatch periodically. Aerate soil to improve water penetration, and apply water heavily in holes every day for 3–10 days. It is possible to eliminate the fairy ring fungus from soil by removing turf and fumigating with volatile fumigants. However this is an expensive and involved process and should be done *only* by licensed specialists. The use of surfactants (wetting agents) may help water penetrate through the area affected by fairy rings.

Seed rot, damping off and root rot

Symptoms. Seeds may rot in the soil or the young grass seedlings may be killed (damp-off) before or after emergence. Seed rot is not mushy but rather dry. In damping-off seedlings at first are water-soaked, then blacken, shrivel, and turn brown. Frequently, affected seedlings are not killed but are yellow and stunted, with markedly reduced root systems.

All types of grasses are subject to seed rot and damping off.

Cause. Seed rot, damping off, and root rot are caused by several species of *Pythium* and/or by *Rhizoctonia solani*, *Fusarium culmorum*, and *Helminthosporium* species.

Seed rot and damping off are favored by excessive moisture, excessive nitrogen, sowing too deeply, and sowing seeds of low viability and above the recommended rates, especially during periods unfavorable for seed germination and growth.

Control. Improve soil aeration and water drainage. Do not overwater. Sow only fresh, healthy seed at recommended rates and seasons. Treat seed with one of several fungicides. Have a qualified expert fumigate soil with a volatile fumigant before planting. Soil fumigation also kills weed seeds, insects, and nematodes.

RODENT DAMAGE in TURFGRASS

Maynard W. Cummings

The damage to turf caused by rodents is perhaps the easiest to identify. The pest animal is usually seen if the observer is patient, but if not the earth mounds or burrows, and cut-off vegetation are unmistakably the work of a sizeable pest.

Rodents may migrate into turf from surrounding areas or, in the case of new plantings, the changed vegetation may provide improvements which favor an increase of rodent populations already there. Some rodent species are mobile enough to cause turfgrass damage while not actually living on the area. In such situations, it may be necessary to apply control measures to surrounding areas, or to protect new plantings by fences or other barriers.

Rodent damage occurs any time of the year, although plant growth stages and rodent breeding and activity cycles affect extent and nature of damage. California ground squirrels undergo periodic winter and summer dormancy, but a percentage of the ground squirrel population is active the year around. The other rodents mentioned in this guide are also active during all months of the year. Turf areas should be frequently inspected for early signs of rodent activity.

NOTE: A description of recommended poisons and gasses to be used for rodent control, as well as methods of application will be found in Leaflet 209.

Typical mound built by pocket gopher or mole—both pests of turf.

A pocket gopher. (It is extremely rare to see one completely out of the ground like this one.)

PEST AND DESCRIPTION	LIFE HISTORY AND HABITS	DAMAGE CAUSED	DETECTION AND CONTROL
Ground Squirrels (genus *Spermophilus*): Several species, commonest being the large "digger" squirrels nine to eleven inches long, tail six to eight inches. Gray and brown mottled color, long bushy tail. Internal cheek pouches opening just inside the lips, for carrying food.	Ground-dwelling but good climbers; may take nuts and fruit but main food is seeds, sprouting grains and green vegetation. Voracious feeders taking two to three ounces green feed daily. Dig extensive burrows which remain open even when animals are hibernating or estivating. These inactivity periods vary with temperature and elevation. Form large colonies, prefer open, grassy, or rocky areas. Breed in late winter and spring, one large (6–12) litter per year.	Store and eat large quantities of seeds, grasses and grain. Dig and eat sprouting grasses. Important reservoir of rodent-borne diseases. Burrows a problem in lawns and ditch banks.	Day feeders so animals are seen. Numerous open burrows three to five inches in diameter. Vegetation cut down and ground bare around burrows. *Poison baits:* Most common control. Best baits determined by testing. *Anticoagulants:* Used where hazard precludes use of poisons, (campgrounds, parks, etc.). Bait and labor costs high. *Fumigation:* Effective when soil is moist, not porous. *Trapping:* Slow for large numbers but effective and safe. Use modified bait station—box traps.
Meadow Mice (genus *Microtus*): Large-bodied, four to six inches, short-tailed 1½ to 2½ inches, dark-colored "field mice." Soft body fur, sparse hairs on tail.	Dig burrows one to two inches in diameter which open straight down, cut runways in vegetation between burrows. Prefer dense vegetation. High reproductive potential; populations cycle radically from few to 1,000/acre. May breed several times yearly. Cut green vegetation just above or just below ground surface. Girdle roots and stems of woody vegetation.	Destroy root crowns and lower stems of clovers, other forage grasses, especially damaging to tubers. Girdle orchard trees, grape vines, other large vegetation. Damage extensive when local populations increase drastically through breeding or migration. Riddle turf areas with holes and runways.	Holes and runways in vegetation. Plant girdling at ground level. Mice seen in daytime when numerous, especially under heavy cover. *Poison baits* sometimes helpful. *Clean cultivation:* Important population check where practical. Orchards, roadsides and ditch bank cover removal reduces breeding reservoirs, reduces migration to other areas.
Pocket Gopher (genus *Thomomys*): Six to eight inches long, tail, three to four inches. Blunt head; small eyes and ears; external fur-lined cheek pouches for carrying cut food; long, slender claws on front feet; large incisor teeth not covered by lips.	Mainly solitary, does not hibernate, digs extensive tunnels four to twelve inches below ground pushing dirt to surface in round or fan-shaped mounds; one litter of two to six young per year except two or even three litters in year 'round warm, irrigated conditions. Prefer legumes and other fleshy stemmed, thick-rooted plants, roots and bark of trees. Cut and eat surface vegetation within a body length of feeding holes but most feeding is underground.	Cut and destroy roots, root crowns, and stems of plants. Gnaw and girdle tree roots. Burrows divert irrigation water, may create erosion problem. Mounds disfigure lawns, smother grass, and damage mowers, furnish seed bed for undesirable plants.	Mounds of fresh earth are unmistakable. Probing near mounds will locate burrows. *Trapping:* Insert two special traps, "Macabee," "California," etc., in excavated burrow, one facing each direction, cover opening, check traps daily. *Poison baits:* Place poisoned grain bait in burrow through probe hold. On large areas treat with mechanical gopher-bait applicator. *Fumigation:* Poorest control method; extensive burrow system makes fumigation difficult.
Moles (genus *Scapanus*): Seven to nine inches long, tail one to two inches. Long slender snout, no external eyes or ears; no cheek pouches; small numerous teeth, do not protrude; soft, velvety fur; short, heavy claws on shovel-like front feet.	Not rodents; soil insects and their larvae, and earthworms are main food items but some seeds, roots, and bulbs are eaten. Prefer moist locations or irrigated areas. Dig deep burrows but also force way through surface soil making ridges above ground. Mound of excavated soil is volcano shape with loose central core. One litter of one to four per year. Almost constant feeders, may eat body weight of insects daily.	Mounds and ridges disfigure lawns and turf areas. Tunnelling cuts roots and dries out sod areas, interferes with watering. Some vegetable matter taken as food, other plants dislodged by digging.	Loose, cone-shaped mounds and upthrust ridges in ground surface. *Trapping:* Best control; use special mole trap "Out-O-Sight" or "Reddick" in surface runways. *Soil Insecticides:* Removal of food supply is effective control on large turf areas unless earthworms are otherwise desirable. Use recommended insecticidal rates. *Fumigation* gives only limited success due to extensive burrow systems. *Poison baits:* Insect-eating habit makes haiting difficult. Most commercial mole baits are of limited effectiveness.

GLOSSARY of TERMS USED

A.—Acre (43,560 square feet)

a.i.—active ingredient—weed killing component in an herbicide formulation.

a.e.—the active ingredient in a herbicide formulation expressed as the acid equivalent.

annual—A plant that completes its life cycle from seed in one year.

biennial—A plant that completes its life cycle in two years. The first year it produces leaves and stores food; the second year it produces flowers and seeds.

broadcast application—An application over an entire area.

broadleaf weeds—Popular term for plants in the dicotyledon group (dandelion, knotweed, plantain, etc.)

compatible—Two or more chemicals or products are said to be compatible when they can be mixed without affecting each other's performance.

contact herbicide—A herbicide that kills only the plant tissue contacted with little to no translocation.

contact insecticide—A pesticide that kills its intended victim when it touches it or is touched by it.

culm—The erect stem of grasses.

dicotyledonae—A botanical subclass in which dicotyledon (broadleaf) plants are grouped.

emulsion—A suspension of one liquid in another, distinguished from a solution in which the two liquids combine completely and become one.

flower stalk—Stalk of a plant bearing a flower.

foliage-applied herbicide—An herbicide the primary action of which is on or through the foliage.

formulation—A manufactured blend of herbicide and other ingredients available as a liquid, wettable powder, or granule for weed control.

fumigation—The use of chemicals put into the soil as gasses or in a form that will turn into gas to destroy unwanted plants (weeds), insects, nematodes, or disease-causing elements.

gal.—Gallon or gallons.

herbicide—A chemical used for killing or inhibiting the growth of plants.

internode—The part of a stem between two successive nodes.

midrib—The middle or main rib of a leaf.

monocotyledonae (monocot)—A botanical subclass in which monocotyledons (narrowleaf) plants are grouped.

narrowleaf weeds—Popular term for plants in the monocotyledon group (all grasses, nutsedge).

node—A joint, as in a stem; the point where buds and leaves occur.

nonselective—The type of weed control that kills plants generally without regard to species on the area sprayed.

ozs.—Ounces.

panicle—A many branched flower head, with flowers at the end of each branch, such as in many grasses (annual bluegrass).

perennial—A plant that lives for more than two years.

postemergence—After germination and emergence from the soil.

preemergence—Prior to germination and emergence from the soil.

preplanting—Anytime before the ornamental or crop is planted.

prostrate—A general term for plants tending to lie flat on the ground.

psi—Pressure; measured as pounds per square inch.

qt.—Quart.

rhizome—A below ground stem with nodes and internodes, usually producing roots and stems or leaves from the nodes.

rootstock—Often used interchangeably with rhizome.

rosette—A cluster of closely crowded leaves arising from a very short stem near the surface of the ground.

seedling—An infant plant grown from seed.

selective—A type of weed control that will kill some plant species when applied to a mixed population without serious injury to other species. Excessive herbicide application rates may reduce or eliminate the desired selectivity.

shoot—A young above-ground branch or growth.

sod—Large sections of turf—usually used in conjunction with production of turf for vegetative propagation.

soil-applied herbicide—Chemicals that are taken up by plants principally from the soil.

soil fumigant—A material used to eradicate all vegetation, usually a vapor or gas that diffuses through the soil and has a relatively short life in the soil.

spike—An inflorescence (flower head) with spikelets (flowers) attached directly to an unbranched stem.

spikelets—A small group of grass flowers; composite a spike.

spot spraying—Application of an herbicide concentration to individual weeds applying no more spray than is required to just wet the foliage.

sq. ft.—Square feet.

stolon—A stem that grows horizontally along the ground, usually rooting at the nodes. A new plant may be formed from each section of stolon that roots.

summer annual—A plant in which the seed germinates in the spring, grows to maturity during the summer, develops seeds and dies during the winter.

surfactant—A material that improves the emulsifying, dispersing, spreading, wetting, and other surface-modifying properties of herbicide formations. Has action similar to that of a detergent.

systemic—When applied to a chemical this means it is absorbed into and distributed throughout the plant. Insects sucking the plant's juices are subjected to the insecticide.

taproot—A stout, vertical root giving off small laterals.

thatch—An accumulation of undecomposed or partially decomposed stems and leaves at the soil surface.

translocation—Movement of materials (herbicide) within the plant from the point of entry to other areas of the plant (such as from leaves to the roots).

tsp.—Teaspoon.

vascular system—The conducting or transport avenues in plant tissue such as the leaf veins.

vein—A conducting or transport unit of the vascular system of plants (leaf veins).

viable—Alive, capable of germinating and growing—generally applied to seed.

weed control—The process of limiting weed infestations so that crops can be grown profitably, or other operations can be conducted efficiently.

weed eradication—The complete elimination of all live plants, plant parts, and seeds from an area.

wetting agent—A compound which when added to a spray solution causes it to contact plant surfaces more thoroughly (see surfacant).

winter annual—A plant in which seed germinates in the fall or winter, lives through the winter in the vegetative stage (often as low rosettes), flower and seed in the spring and summer, and die by winter.

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